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ABSTRACT

This study addresses the placement of students in remedial education among community colleges in the United States. Of specific interest is the appropriate entry-level placement of students in math courses. Citing that traditional standardized placement tests are overly broad and thus of questionable value for placing community college students in entry-level algebra and arithmetic courses, the purpose of this study was to create and test a tool designed specifically for the placement of students into such classes at technical colleges across the state of Ohio. The resulting tool was named the Arithmetic Achievement Test (ATT). The ATT was administered to a total of 415 students enrolled in entry-level algebra classes at six, two-year technical colleges in Ohio. Scores on the ATT were then compared with the students' final test scores and course grades. Based on the analyses performed on the given sample of students, results indicate that the ATT may be a useful tool as used for placement of students in arithmetic and algebra courses at two year colleges. Individual differences between each of the six colleges are discussed, as is the role of student motivation. (SKF)

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ED 430 593

THE ARITHMETIC ACHIEVEMENT TEST
AND THE EFFECTIVE PLACEMENT OF
STUDENTS IN MATHEMATICS

A Dissertation Presented to
The Faculty of the College of Education
Ohio University

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Philosophy

by
Bruce D. Jones
June 1997

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CHAPTER ONE

Introduction

The issue of how to deal with the ever-increasing numbers of students who are unprepared for college-level work is a source of unending controversy for America's two-year colleges. This is true in spite of the fact that these borderline or at-risk students are the very reason these schools have enjoyed increasing enrollments for the past forty years and that assisting these students is a major part of the mission of most of these institutions. Many critics of American education (Rouche & Baker, 1987; Feinberg, 1984) complain of the dilution of the curriculum and the lowering of standards which come with the admission of such students. The most critical commentators maintain that the admission of borderline students means an *inevitable* lowering of standards. Others question whether these adjustments of standards are inevitable at all (Mickler & Chapel, 1989; Dodson, 1987). Still others complain of the lack of success that these students have in the classroom, and question whether it is wise to expend so much of any college's resources in what they see as an effort doomed from the start for most remedial students (Richardson, 1983; Clark, 1960). Politicians on all levels of government (e.g. Senator Thompson, Senator Coolahan, Rep. Scherer, Rep. Lumpe) often argue against having to pay a *second time* for an education the student was already given in the public schools (Jaschik, 1985). In response to such criticism, many education professionals (Dodson, 1987; Borst, 1984; Chand, 1985) point to programs which have demonstrated they can help the at-risk student succeed. Many educators (Rouche, 1987; Mickler & Chapel, 1989) also believe it unethical to systematically exclude anyone from participation in higher education. In a society which is increasingly egalitarian, it seems somehow unAmerican to disenfranchise such a large portion of society. Most feel a sense of obligation to the large number of under-prepared students who desire a college education.

At this current juncture in American education, the customary way to deal with students who are not yet ready for college is to separate them out in some manner from the general population and require them to participate in some form of remedial education. Remedial programs now exist in virtually all two-year colleges (Ansley, 1991), and these programs have been in place for some time. One national study (Florida State Board of Community Colleges, 1994) found that at least 91% of all public colleges offered remedial courses. McDonald (1988) found in a national survey of 46 two-year schools that there were no developmental programs less than two years old, and only two programs less than six years old. Despite some lingering controversy regarding the admission of *unqualified* students, remedial programs have become fully ensconced in America's two-year colleges, and while many have been successful, no single program or single methodology currently can claim to be the overwhelming favorite, or to have even attained a general widespread approval.

"Many colleges are now requiring students who as a result of testing indicate a need for remediation, to take remedial work before they are allowed to enter college-level courses" (Dodson, 1987, p. 59). In fact both Dodson (1987) and Mickler and Chapel (1989) have found that the popularity of such programs is on the rise and that the number of schools with such policies in place is increasing. Most of the growth in the numbers of these programs is at four-year colleges, however, with a smaller but growing number of two-year colleges adopting such policies. Ansley (1991) found that only 12.3% of the two-year schools served by the Southern Regional Education Board (SREB) had such programs in place. These programs usually require students to raise their skills up to some predetermined standard prior to admission to college. Some remedial programs, such as the one at Miami-Dade Community College (which has gained some significant attention for its successes), not only restrict students from taking any college-level work but also place remedial students under strict credit load limits (Mickler and Chapel, 1989).

While Miami-Dade and other institutions have demonstrated the effectiveness of programs which require students to make up deficiencies prior to beginning college-level work, many other programs allow students to *catch up* on their remedial work while simultaneously being allowed at least to start their regular college-level programs. Ansley (1991) found that 22.3% of the colleges served by the SREB had such policies in place. These programs contained at least some restrictions on what remedial students are allowed to take, however. If certain course work is to be required of students, then it is necessary to devise some form of screening which as accurately as possible determines which students are in need of remediation.

Many states have begun to require some form of standardized testing to take place prior to admission to or graduation from even a two-year college. Although the number of such programs is growing, and this trend shows signs of continuing at least in the short term, these programs contain some significant differences. New Jersey requires testing prior to admission and then makes recommendations as to appropriate course work. Texas also requires testing prior to admission and mandatory placement into remedial classes where it is appropriate. Florida requires all students to take a basic skills test prior to admission and then to pass an exit exam before they are permitted to graduate. All of these programs, and similar ones in other states, are designed to deal with the rising tide of remedial students and insure the maintenance of a minimum standard.

Most of the institutions (two-year and four-year) which have put remedial education policies into practice predictably also require the testing of students. Lederman, Ribaudo, & Ryzewic (1985) in a national survey, found more than 98% of schools believed testing to be necessary. Of all colleges, 75% used placement testing; of those schools with mandatory placement, over 90% required testing. By 1989, nationally over 90% of all colleges required placement testing (Florida State Board of Community Colleges, 1994). Testing is in place partly because of expediency- it is the cheapest, easiest, and least time-consuming method of determining a student's basic skills. It has also gained such widespread support, however, "because, frankly other data...is frequently unreliable, insufficient, or non-existent" (Morante, 1989, p. 2). There are other possible alternatives, but too often they are difficult for one reason or another to implement. For example, Wattenbarger and McLeod (1989) found a clinical interview and evaluation method for determining course placement to have a high success rate, but the plan was far too cost prohibitive to be employed on any widespread basis.

There are a few educators, however, who do not find testing to be a legitimate method for determining course placement. Wattenbarger and McLeod (1989, p. 18) believe that "the use of standardized college entrance examinations has not proved to be an effective device for placing entering students into appropriate courses in the curriculum." Wambach and Brothen (1990, p. 24) complain of "the lack of a strong relationship between skills tests and grades" and believe that this "calls into question the assumption that skill levels can be validly measured." The same article questions whether it is even possible to differentiate between students who can succeed with intervention and those who can succeed without it. "Success in the classroom", they say,

> is determined not only by the students' skill levels, but also by the amount of time and effort the student is willing to spend and how well the student can compensate for deficiencies of one kind with strengths of another. These coping mechanisms are not measured by brief tests. (Wambach and Brothen, 1990, p. 24)

While well-intentioned and certainly raising some valid points, these individuals also expose the weakness of their own argument. Is it not better for both the student and the educational institution if these deficiencies are exposed, thus enabling the student to correct them, rather than allowing him/her to struggle and somehow "compensate" for them or "cope" with them? Learning should not be an activity where a defense "mechanism" must kick in to save the person from undue stress, anxiety, and ultimately, failure. If the skills taught in remedial programs are truly necessary and beneficial, then educators are certainly obligated to expose weaknesses to the student, so that s/he may better deal with them and thereby both increase his/her academic prowess and build his/her self-confidence. The coping/compensating strategy is negative, reactive, and possibly even detrimental to the student. Remedial education at its best should encourage students to overcome their weaknesses. This approach is positive, proactive, and certainly best serves the needs of the student in the long run.

For many years now, underprepared students have been enrolling in the nation's colleges. Two-year institutions in particular have been undertaking the mission to assist those students who come to college lacking in essential basic skills. National estimates from the Department of Education for the year 1989-1990, the most recent data currently available, indicated that 30 percent of all entering college freshman took at least one remedial course (Florida State Board of Community Colleges, 1994). The percentage of students needing remediation at two-year colleges, however, is no doubt even higher. Karl Bougham (1995) found that 59% of the students in Prince George's Community College needed remediation in at least one area. The Florida State Board of Community Colleges (1994) found that about 50% of students in Florida's community colleges needed remediation in at least one area. Gable (1987) found that 54% of students in community colleges in Texas needed remediation in mathematics.

With numbers which seem destined only to increase, the question for colleges is how to deal appropriately with students who demonstrate a need for remediation. Placing students into remedial courses seems to be the solution of choice, and it appears that it will continue to be for at least the foreseeable future. For a student to have the best opportunity to reach his/her potential under this system, it is absolutely essential that s/he be initially placed at the proper point in his/her remedial work. This is especially true in mathematics because of its hierarchical structure and sequential nature.

If a student is placed too low in the mathematics curriculum, s/he will at best be bored. Even worse, s/he may feel s/he is being unduly penalized and frustrated, or s/he may sense that the college does not see him/her as an individual. S/he may drop the class or even try to avoid mathematics altogether. If a student is placed too high in the curriculum, the consequences can be even more devastating. The student will have little chance of success, and even if s/he does somehow pass the course, s/he will likely not be able to apply what s/he has learned.

Remedial students often lack self-confidence, and being asked to perform at a level beyond their capabilities certainly will not help matters. A negative experience may be taken as yet further evidence of their own lack of ability. An all too common scenario is that the student will become completely frustrated with the course and perhaps mathematics in general. The student may grow apathetic and even withdraw from the class, perhaps even from school, or worst of all from formalized education or any situation where s/he is likely to encounter mathematics. This may seem somewhat overstated, but many of these students see the two-year college as their last chance at educational success. Often they come to college with their last shred of confidence to give it one final try. It does not take much to break such a fragile spirit. A negative experience for a student who does not believe in him/herself can turn an attitude of failure into a self-fulfilling prophecy.

Statement of the Problem

What is needed is an improved vehicle to improve the probability that students get correctly placed into a mathematics curriculum. At the vast majority of institutions in this country, the placement instrument of choice is the placement test. Indeed, at most institutions this is the only instrument utilized. Yet in spite of their popularity, there is reason to doubt the value of these placement tests, particularly in the area of basic skills where "little work has been done with empirical procedures to look at deriving cut-scores for placement decisions regarding basic skills competencies" (Weber and Twing, 1986, p. 1). The commercial standardized tests that are used now are too broad based and seem to have little value in placing students into entry-level algebra and arithmetic courses.

What is needed is a standardized test which examines only the basic aspects of arithmetic, most or all of which would likely be included in all two-year curriculums. This test needs to pinpoint those skills which are the most crucial to a student's success in entry-level mathematics courses, and identify whether or not those skills are missing. Students coming to many of today's two-year colleges often vary widely in their ability levels, even in a seemingly narrow and specific area such as arithmetic. Students currently often spend two or three quarters in remediation before they can begin even an elementary algebra course. Accurate identification of those students who need remediation is crucial if they are to gain access to the tools they will need to succeed.

A thorough literature search revealed no instrument which is completely appropriate for placing students into entry-level courses in a two-year school's mathematics curriculum. The instruments that currently have been tested across institutions are simply inappropriate or have too little correlation with students' performance in the classroom. In-house tests are often used but are rarely tested at even a local level, much less beyond. Yet schools continue to place students into mathematics classes using these tests. This results in misplacement, which can be extremely detrimental to students. What is needed is a test which consists of appropriate material that has a high degree of predictive value and which has been tested beyond the local level so that it may be used with a wider audience.

Purpose of the Study

The purpose of the study is to provide technical colleges across the state of Ohio with a high-quality tool for the placement of students into entry-level algebra classes: an instrument which will be valid for each institution and which will provide valuable information on the placement of each institution's students. This includes information on students' arithmetic abilities, optimal cut-scores, grey areas where placement is uncertain, and error rates. It will also give institutions an instrument which is normed against a larger population, providing comparative data across six of the nine technical colleges in the state.

This study has produced a test that is specifically geared to arithmetic skills, something in which more and more incoming students are sorely lacking. Furthermore, by using the test across various institutions, some normative data was also acquired. It was hoped that the correlation factor across all institutions would be greater than r=.35. This figure was chosen for two reasons. First, it was chosen because California, the state with the largest two-year college enrollment, has set r=.35 as the benchmark which any placement test must reach to be given state approval. Second, this score is higher than that found for the ASSET Test in the studies conducted by the American College Testing Program (1994).

(The ASSET Test is currently the most widely used placement instrument in the United States in two-year colleges.) It was also hoped that the test produced through this research would at least match the ASSET's level of 67% correct placement through the use of an optimum cut-score procedure.

If a standardized test with the attributes discussed above can be created, it would be a valuable tool for any two-year school faced with placement decisions and large groups of under-prepared mathematics students. It is hoped that the Arithmetic Achievement Test (AAT) developed for this study will be such a test.

Research Questions

In an attempt to address the issues raised in the area of placement tests for remedial mathematics, this study will attempt to answer the following questions.

1. Is the correlation between the AAT and the final average grade of students in entry-level algebra courses across the same institution equal to or greater than r=.35?
2. Is the correlation between the AAT and the final exam grade of students in entry-level algebra courses across the same institution equal to or greater than r=.35?
3. Is the correlation between the AAT and the final average grade of students in entry-level algebra courses across all institutions equal to or greater than r=.35?

4. Is the correlation between the AAT and the final exam grade of students in entry-level algebra courses across all institutions equal to or greater than r=.35?
5. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67% or higher) when non-completers are ignored (across all introductory algebra classes in the same institution)?
6. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67%) when non-completers are included (across all introductory algebra classes in the same institution)?
7. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67% or higher) when non-completers are ignored (across all institutions in the study)?
8. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67%) when non-completers are included (across all institutions in the study)?

Hypotheses

$H_0$1. The correlation between the AAT and the final average grade of students in entry-level algebra courses across the same institution is equal to r=.35.

$H_0$2. The correlation between the AAT and the final exam grade of students in entry-level algebra courses across the same institution is equal to r=.35.

$H_0$3. The correlation between the AAT and the final average grade of students in entry-level algebra courses across all institutions is equal to r=.35.

$H_0$4. The correlation between the AAT and the final exam grade of students in entry-level algebra courses across all institutions is equal to r=.35.

Definition of Terms

ASSET Test

When the author refers to this test both in this study and research conducted specifically by American College Testing Program (ACT), it specifically is the numerical skills portion of the ASSET Test published by ACT.

At-Risk Student

While there are a number of facts that may place a student at risk, in the context of this paper, it is taken to mean students whose current basic skills (reading, writing, and mathematics) are deemed to be insufficient to allow them to do college-level work. These students are also referred to as borderline, underprepared, or unprepared students.

Basic Skills

This generally refers to reading, writing, and mathematics. In regards to mathematics, the author uses the term to refer specifically to arithmetic skills. When referring to others' research, however, it may be expanded to include a variety of topics generally considered to be at the high school level. These would include but not be limited to algebra, geometry, and elementary trigonometry.

Completers

A completer is an individual who did not drop the course, but rather who finished the course as evidenced by completion of the final exam. This student did not necessarily pass the class successfully.

Cut-Score

This is the score used by educators to determine placement. Students scoring below the cut-score are deemed not ready for a given class, while those scoring above it or equal to it are deemed ready.

Entry-Level Mathematics Classes

This refers to any number of classes in which a student can enroll with no special skills other than an ability in arithmetic. It also refers to those remedial classes into which remedial students would normally be placed.

Existing Success Rate

The percentage of students that could be expected to pass a course if no placement instrument were assumed to be in use. For instance, in a given group of students, 83% pass a given course. If no placement instrument were used, and all students were placed into the class, 83% of the students would have been placed correctly since they passed the class. Therefore, 83% would be the existing success rate.

Final Grade

The percentage of points the student earned of the total points possible.

Failure

Failure for a student is any grade below 70% (C-).

In-House Test

These are tests which are created at and utilized solely by individual institutions for the purpose of placing their own students at the proper point in the institution's curriculum. They are also referred to as localized, locally developed, or institutionally developed tests.

Passing Grade

Only those students who finish the course with a grade of at least a C- (70%) will be said to have passed the class or achieved a passing grade.

Placement Test

This refers to any instrument used for placing students into a mathematics curriculum. This would include not only the AAT, but also commercial standardized tests such as the ASSET Test, the MDTP, the ACT, and the SAT.

Prediction Success Rate

The percentage of students which would have been correctly placed if one followed the dictates of a cut-score from a given placement test. For example, a prediction success rate of 78% means that 78% of the students would have been correctly placed using the given criteria.

Remedial Mathematics

When it applies to the author's research, remedial mathematics refers to arithmetic and other *pre-algebra level* subjects. This would include topics such as operations on whole numbers, fractions, decimals, percents, order of operations, operations on integers, powers, roots, and elementary arithmetic applications. When used by other authors cited in this study, it may include additional topics which are generally thought of as high school level work and below, in particular, topics in elementary algebra.

Remedial Programs

This applies to any program designed for students who are deemed to be underprepared for that specific institution's program. Although it may vary widely from institution to institution, it may generally be construed as those programs including high school level work (and often below) in the basic skills areas.

Successful Completion

As applied to the author's research, this means that a student completed a given mathematics course with a grade of at least a 70% (C-). Students succeeding will be said to have *passed* the class. A student succeeding will be considered properly placed; a student not succeeding will be considered incorrectly placed.

Technical College

This is a college whose mission, in part, is to prepare students for entry level positions in a number of different technical fields. The approach of the programs at these institutions is decidedly vocational in nature and the approach to mathematics is highly application oriented. The degrees granted by such institutions are usually designed as terminal degrees. The level of expertise gained by the successful student is sufficient to allow him/her to be competent in an entry-level position in the technology for which s/he was trained. The legal name of these institutions carries the word "technical" as mandated by Ohio law.

Two-Year College

This refers to any institution that grants Associate degrees, but neither generally offers or is directly affiliated with any institution that does offer a Bachelor's degree. In general terms, this would include most technical and community colleges while excluding two-year branch campuses.

Significance of the Study

In a thorough review of the literature no test was found which: 1) is geared specifically toward arithmetic; 2) has been rigorously tested beyond the local level, and 3) has demonstrated a high degree of correlation to actual student performance in the classroom. Such a tool has the potential to improve significantly the placement of remedial students into the mathematics curriculum. It is hoped that this study will result in such an instrument; a tool for appropriately placing students into the arithmetic portion of a mathematics sequence at a two-year college while simultaneously providing participating institutions with information on how it may be correctly utilized at their individual institutions. Furthermore it is hoped that it, in turn, will give some normalized standards whereby these institutions may compare themselves to similar institutions utilizing the same placement instrument. As no other instrument of this type has been tested beyond the local level, it may also be the starting place for further research which may either refine the present instrument under study, or use it as a starting point in further defining this area of placement.

Assumptions and Limitations of the Study

As this study examines the correlation between the test instrument (AAT) and students' final grades, there are some limitations. First of all, even if one finds a strong correlation, there can be no automatic extrapolation to any interpretation that is causational in nature. Also, there are many other factors which obviously influence a student's performance. These include, but are not limited to: the student's desire and work ethic, his/her time available to apply himself/herself to his/her mathematics course work, high school grade point average (GPA), number of years since the student was last in a formalized instructional setting, and the student's overall attitude toward school in general and mathematics in particular. The purpose of the study, however, is to design a tool which may quite possibly be used in conjunction with a variety of tools measuring many of these *other* aspects that may be related to student performance. In addition, it must be noted that there are other factors such as the quality of instruction, class size variations, and other intervening variables which this study is unable to control for through randomization.

Delimitations of the Study

This study is concerned only with the placement of students into mathematics curriculum in the two-year technical college. Generalizations beyond this scope such as to other areas of study or other types of institutions are perhaps possible, but should be undertaken with some caution.

Organization of the Study

Chapter One introduces the research topic and includes also the research questions, the hypotheses (in null form), the statement of the problem, the purpose of the study, definitions, the significance of the study, assumptions and limitations of the study, and delimitations of the study.

Chapter Two contains the review of the literature.

Chapter Three contains the methodology of the study, including the sample, the test instrument (AAT), data collection, and proposed analyses.

Chapter Four contains the results and discussion of those results as well as recommendations for future research which might clarify and extend upon the results of the current research. Although this is an unusual format, it was necessary to maintain the flow of the paper. With so many individual analyses, it seemed logical to present the results from each and to follow immediately with an analysis of that data. If a traditional format had been used all the results would be given in chapter four, and the reader expected to recall individual details from nearly a dozen separate analyses when reading analyses in chapter five.

References and the Appendix follow the main body of this dissertation.

CHAPTER TWO

Review of the Literature

An Historical Perspective on the Preparedness of College Students

Although most often thought of as a relatively contemporary issue, the plight of under-prepared students and how faculties should deal with them have plagued colleges for centuries. The faculties of the first colleges in early colonial America complained of the poor preparation in Latin among their incoming classes and blamed the Latin schools. Although remediation in those times was more informal, the history of formal remediation is also not as short as perhaps the average educator today perceives it to be. In 1852, Henry Tappan, in his inaugural address as the new president of the University of Michigan, complained that American colleges as a whole were far too involved in the teaching of rudimentary courses. He felt that the standards of his institution had been lowered in order to admit such students. He stated that, "to turn raw undisciplined youth into the University to study the professions, to study the learned languages and the higher sciences is a palpable absurdity" (Maxwell, p. 7).

A decade after Tappan's address, Iowa State College established a preparatory department and began to require all incoming freshmen to undergo evaluation of their reading, writing, and arithmetic skills. If they were found lacking in these areas, they were sent to the preparatory department for assistance. In 1874, Harvard University began offering an

English course for freshmen who were found to have substandard skills in formal writing. In 1890, the College Entrance Examination Board was founded for the purpose of standardizing admission requirements. In the earliest years of the 20th century, students were scarce, and competition for students was intense. Many complained that colleges were sacrificing quality in order to fill seats in their classrooms. In 1907, over half of all students matriculated at Harvard, Yale, Princeton, and Columbia failed to meet admission requirements. In 1915, 350 colleges reported to the United States Commissioner of Education that they had college preparation departments. Many colleges laid the blame for the poor preparedness of students coming out of the nation's high schools on the paltry budgets those high schools were forced to deal with. During the 1930's, many colleges and universities established remedial reading clinics, labs, and courses. Included among these were the University of Minnesota in 1934, New York University in 1936, and Harvard in 1938 (Maxwell, p. 8-9).

Enrollment in American colleges began to increase dramatically after the end of World War II. First the G.I. Bill and later the Baby Boom kept a steady stream of students heading into America's hallowed halls of education. In addition to raw numbers, the percentage of students finishing high school and going on to college was rising steadily. It was during this time period that community and junior colleges became rejuvenated. Consequentially the number of these institutions and of students attending them began to rise dramatically. Behind the sheer magnitude of the numbers, however, lay some disturbing figures. In 1961, Shaw found

> the prevalence of reading and study deficiencies among college freshmen were alarming... 68% were never taught to read a chapter effectively; 70% had not been taught to concentrate on a reading activity; and 70% had not been taught to evaluate a writer's basis. Two thirds of the freshmen lacked the reading skills required for college success; 95% lacked the study skills. (1961, p. 336-337)

Although these statistics seem somewhat alarmist in nature, they seem to blend in well with similar rhetoric uttered today on many college campuses.

Although history is replete with examples of college remediation, the need for such programs, and the social forces that brought them on, the last thirty years have brought us to perhaps the most challenging period in the history of higher education in this country. The civil rights movement brought large number of minority students to the nation's campuses eager to take advantage of their new found freedom and its accompanying opportunities. Although few doubt the motives of the many courageous educators pushing for equal opportunity, and fewer still the moral certitude of eliminating racial discrimination, none can doubt that many of the minority students who have come to campuses since the civil rights movement have been poorly prepared. In addition to minority students, more women began entering colleges as well, and the median age of students began to rise as older students began returning to educational environments in increasing numbers. One could no longer identify who the typical American college student was, and the qualities s/he possessed. Social forces during this period have forever changed the *complexion* of higher education.

The Open Door

Since the University of Minnesota was ordered to begin admitting all high school graduates in 1934, many institutions of higher learning have embraced the "open door". Today most two-year schools have open admissions policies.

> Give me your tired, your poor, your huddled masses yearning to breathe free. The wretched refuse of your teeming shore, send these, the homeless, tempest-tossed to me. I lift my lamp beside the Golden Door. (The words of Emma Lazarus inscribed on the Statue of Liberty, from Rouche and Baker, 1987, p. 1)

Although the words of Emma Lazarus seem somewhat insensitive and harsh in the light of 1990's cultural pluralism, they still reflect to some degree the sentiment still alive today in many of America's two-year colleges. Today, a message of encouragement and invitation goes out from America's two-year colleges to those students whose skills and preparedness do not qualify them for traditional colleges. While it is true that many traditional and mainstream colleges are making valid attempts to deal with the problem, few would contest that it was originally the

> who seek higher education (Ohio Federation of Teachers, 1994(a), p. 3)

The open door admission policies and the egalitarian philosophies that spawned them are the mainstream of American education today.

Edward Sullivan, Chair of the New York State Assembly Higher Education Committee, recently cited America's "attempts to educate those who have never been educated before and are denied access to education in other areas of the world" (Ohio Federation of Teachers, 1994(b), p. 2). Others acknowledge that, "open access schools are not even attempted in other countries" (Ohio Federation of Teachers, 1994(b), p. 2). "Accessibility for all students who desire an education is one of the basic tenets upon which the [American] community college was founded and continues to exist" (Dodson, 1987).

The concept of open education seems a natural fit in American philosophy. To argue against access to educational opportunities for all citizens goes against our egalitarian philosophy and somehow seems downright un-American. Mickler and Chapel question the fairness of exclusive enrollment practices and ask if "students should be penalized for a lifetime because they did not acquire basic skills [in high school]" (1989, p. 4). "To suggest that the unmotivated 16 year-old high schooler never becomes a motivated 25 year-old, who sees the value of education, is sheer fallacy" (Mickler and Chapel, 1989, p. 3).

The open door, however, is not without its critics, and many question nation's two-year schools who made the biggest inroads in helping the poorly prepared student, and that their role in this area is increasing. Miss Liberty's *Golden Door* represented a gateway to opportunity and the chance for a better life to the nation's immigrants in the last century. During the present century, the open door has held out a similar promise, beckoning to society's many underprepared students and underprivileged citizens.

Few would doubt the importance of an education in modern American society. Social and cultural forces have brought us to the place where few would openly deny anyone access to higher education. Even John Rouche, who has been unabashedly critical of the current state of open admissions and remedial education in this country, when speaking in regard to access to higher education has said that "in accordance with democratic ideals, every human being should be allowed, if not encouraged, to develop to his fullest potential" (Rouche and Baker, 1987, p. 1). K. Patricia Cross has identified three distinct philosophies which have evolved over the course of American education: the elitist aristocracy, the meritocracy, and egalitarianism.

> The elitist aristocracy held that only the wealthy who needed education to maintain their station in society should go to college. This was characteristic of the earliest higher education in the U.S. This philosophy eventually gave way to meritocracy- the belief that only those individuals of academic merit should go to college. The most recent philosophy of higher education in the U.S. is that of egalitarianism. Egalitarianism calls for open door admissions to all

the value of admitting underprepared students. Feinberg, a columnist for the Washington Post, writes that

> to say that there should be universal access to college seems fair. It seems egalitarian, but it's been destructive because students think you do not have to strive in high school. There's the illusion that you can recover, so the whole level has dropped. (Feinberg, 1984, p. 6)

Indeed many complain that standards have been sacrificed at the altar of open admissions. Richardson (1983, p. 1) asserts "the open door of the community college too often becomes a revolving door when students' needs are not met and program quality decreases." Clark (1960, p. 162) argues that "the disjuncture between ends and means, between the open door and standards, dooms large numbers of students to failure." It is precisely this battle between the desire for the maintenance of standards versus the desire to maintain an open door for all who desire an education that led Hughes (1991, p. 42) to state that "community colleges, more than any other segment of higher education, continue to experience instability, and a lack of a clarity of mission."

Many argue that because two-year colleges admit remedial students, the "level of difficulty has been reduced in *normal* classes to deal with the poorly prepared students" (Feinberg, 1984, p. 7). Rouche, Baker, & Rouche (1987, p. 23) report that the presence of underprepared students in the classroom has encouraged instructors to lower their standards. They found "overwhelming evidence that college instructors routinely were lowering course requirements to keep students from failing." At the same time, however, Rouche and Baker believe that "the demand to educate everyone up to the level of his ability and the demand for excellence in education are not incompatible." It is their contention that "we must honor both goals. We must seek excellence in a context of concern for all" (Rouche & Baker, 1987, p. 5-6).

Many have begun to question the cost efficiency of the remedial programs which are necessary to maintain an open door. Senator Richard Thompson (R), while a member of the Indiana Senate, expressed what seems to be an increasingly popular belief that "remedial programs at colleges should be eliminated because they are more expensive than they would be at high schools where students live at home and staff salaries are lower" (Jaschik, 1985, p. 20). Representative Jim Scherer (R), chairman of the Education Committee of the Colorado House of Representatives, stated his opinion that "we should be spending our time and money on educating those people who have already demonstrated the ability to learn" (Jaschik, 1985, p. 20). Senator John C. Coolahan (D, Maryland) has said that "when you get to college, you either cut the mustard or you get out" (Jaschik, 1985, p. 21). Grable (1988, p. 2) cites the fact that in the Texas Legislature "questions began to be raised concerning the effectiveness of the community college remedial efforts." It seems logical to state that in these times of changing political climate, the desire to decrease budgets and taxation could likely spell the end of the open door if educators are unable or unwilling to show solid results. Perhaps the harshest critic to date is Ms. Lumpe, who serves on Missouri's House of Representatives Appropriations

Committee. She believes that "the main reason college officials favor remedial programs is that administrators are trying to fill their buildings and they do not want to lose any students." Furthermore, "when state higher-education officials present their budgets each year, [Ms. Lumpe asks] how much is for remediation and tries to eliminate [that amount]" (Jaschik, 1985, p. 20).

The Need for Remedial Education

What most laymen, and even some educators, are unaware of is the extent of the problem. In a national survey cited by Bray (1987), 85% of educators from various two-year and four-year institutions perceive poor preparation to be a major problem among incoming freshmen. Plisko and Stern (1985) in a survey of freshmen at both two- and four-year schools determined that approximately one third of entering students need remediation in reading, writing, mathematics, or some combination of the three. Ansley (1991) found that 36% of those freshmen entering two- and four-year schools in the state members of the Southern Regional Education Board needed similar remediation. Mickler and Chapel (1989) also put the number at one-third. However, depending on how one chooses to define competent, developmental, and other such illusive terms, the population involved, and a variety of other factors, the numbers can vary significantly. Evangleauf (1985), citing statistics in California, states that 53% of freshmen in the California State University System need remedial math. Losak (1982) found 62.5% of freshmen entering Miami-Dade needed at least one remedial course. Morante (1982) found that 68% of freshmen entering New Jersey's two-year and four-year colleges were deficient in arithmetic, and 89% were deficient in elementary algebra. Sworder (1990) reported that at El Paso Community College, 98% of freshmen were unprepared to begin college-level math.

The U.S. Department of Education (1990) found that only 46% of the country's graduating seniors could solve problems involving fractions, decimals, percents, elementary geometry, and elementary algebra (all problems presented to students were considered to be seventh-grade level work). The same report found that "when the mathematics became at all complicated, performance fell off dramatically." They found, for instance, that only 5% of graduating seniors could do problems in geometry, algebra, probability and statistics. (U.S. Department of Education, The State of Mathematics Achievement, p. 8).

The Effectiveness of Remedial Education

Results of studies designed to determine the effectiveness of programs on the local, regional, and even national levels over the years have demonstrated that there is no easy answer to the question of effectiveness. Results have been, to say the least, extremely mixed. Consider a 1989 study conducted by Barr and Parker (1989) which found that prior to remediation, 23% of students ranked their own mathematics ability as either poor or very poor. After remediation, however, only 10% rated themselves as such. Gains in test score averages ranged from a minimum of 27% to a high of 98% depending upon the area of mathematics in which the students were receiving remediation. In this same study, however, Barr and Parker (1989) reported that even with these tremendous gains, the remediated student still lagged behind the average student in terms of entrance scores for the next higher math class in the sequence. They also reported that only 50% of the students successfully completed their remedial mathematics course; the comparable rates in reading and writing were 67% and 70% respectively.

Other studies on the effectiveness of remedial programs, however, have shown results that are anything but mixed. Losak (1982) at Miami-Dade Community College found that less than one-half of all students needing remediation even returned the next quarter. In similar studies Losak and Morris (1982) and Belcher (1984) found the same results at Miami-Dade. Oromaner (1985) found the same to be true at Hudson Community College in New Jersey. Haase and Chaffrey (1984) showed that students reading below the tenth-grade level had little or no chance of receiving even a "C" in any class except those created to meet the specific learning-skills deficit of the student. Studies by Barr and Parker (1989) and Einspruch and Downing (1990) indicate that barely half of those students who enroll in remedial mathematics courses successfully complete them.

Conlin (1989) reported that at Southwestern Community College, 85% of those students who needed basic grammar and 74% of those students needing basic math dropped out of college. Lyons (1990) found that even after completing remedial course work, students were not able to compete with those students who were able to bypass the remedial work. Gabe (1989) found that at Boward Community College students who needed remediation prior to beginning a college-level mathematics course had successful completion rates of only 11% and 16% in that course over each year of the two-year study. Sturtz and McCarroll found that of 322 freshmen enrolled in Basic Mathematics I at South Central Community College, barely half made it successfully through the course and enrolled in Basic Math II. Barely half of these in turn made it through to their college-level math courses. Sworder (1990) found that only 41.5% of the students enrolled at Saddleback College were successful in their arithmetic course, and only 51.6% in elementary algebra. Stutz and McCarroll (1993) found that only 63% were successful in a basic mathematics course.

Belcher (1984) reported that only 14% of those who entered Miami-Dade Community College in Fall of 1981 with deficiencies in writing were able to pass the CLAST test (required for graduation from any Florida Community College) by March 1984. The comparable success rates for students entering with deficiencies in reading and math were 13% and 12% respectively. Losak and Morris (1982) demonstrated that those entering with basic skills scores in the highest quartile had a retention rate 50% higher than those students in the lower quartile after only 1 quarter. Furthermore the graduation rate for students failing all three basic skills tests was only 3.86% after two years, while it was 26% (or seven times higher) for students who passed all three skills tests. Losak (1982) also demonstrated that the retention rate for those who passed all three tests was 30% higher than for those students who passed none.

There are equal numbers of studies that seem to contradict these results, however, which suggests that there is hope for remedial programs and the students who enroll in them. Dodson (1987) cited three separate studies by Hoban (1983), McCadden (1983), and a 1982 study conducted at New River Community College, all of which indicate that developmental students attain a higher average in subsequent classes than students who do not require remediation in that area. Haase and McCaffrey (1984, p. 24) demonstrated that the "process utilized at Sacramento City College has had a positive measurable impact on the success and retention rates of students in selected courses."

Borst (1984, p. 1) found that the withdrawal rate was dramatically reversed by the implementation of a "skills prerequisite system." The withdrawal rate for all students dropped from 38% in 1977 to only 21% in 1983. Furthermore he concluded that although "we have increased our cost 'up front'; [we have] decreased our cost and waste of human potential 'out-back'" (Borst, 1984, p. 7). A study at Miami-Dade conducted by Rouche, Baker, & Rouche (1987) found that retention among blacks increased by 50% after implementing a developmental program. Belcher (1984) found that 19% of entering students failed all three basic skills areas. If these students persisted and took the CLAST test, 81% passed. Chand (1985) found that by implementing some instructional and format changes in Triton College's arithmetic classes, success rates increased from about 50% to more than

70%. They accomplished this remarkable rise while simultaneously stiffening the standards to which students were held. Students had to meet a benchmark of 80% on a test before moving on to the next section of the course. Word problems were included on all tests. Furthermore, they found that 90% of those students passing at least one developmental course returned to Triton College and 24% persisted until graduation.

Morante (1986, p. 14), reporting the results of studies done by the New Jersey Basic Skills Council, stated the "council concluded that the 'completers' [those successfully completing the prescribed remediation] had virtually the same probability of passing college-level courses as nonremedial students." He also found the retention rate was 90% for completers compared to 83% for those not needing remediation. After four semesters the completers had a retention rate of 55% compared with 51% for those not needing remediation at New Jersey community colleges. At the state colleges the rates were 75% for completers and 70% for those able to bypass remediation. The successful survival rate, or the percentage of students still enrolled after four semesters with a GPA of 2.00 or higher, was 37% for the completers in community colleges versus 40% for those not needing remediation. In the state colleges, the comparable figures were 58% for completers and 63% for those able to bypass remediation. Simmons (1994)identified a summer transition program conducted for 86 at-risk students. Following the transition program, 51 of these students got C's or better in their course work. Of those enrolled in Fall '89 and Fall '90, none had dropped out by Fall '93. Rounds and Anderson (1985) report that

Clackamas Community College reduced attrition among students in the lowest quartile by 75%.

Carlette Hardin, Director of Developmental Studies at Austin Peay in Clarksville, Tennessee, has been an eloquent defender of developmental programs and the students they serve. She states several assumptions about developmental students. Included in these are three keys:

> 1. Developmental students are underprepared. Being underprepared, however, does not equate with incapable or ineducable.
>
> 2. Developmental students can overcome their deficiencies when placed in appropriate remedial or developmental courses.
>
> 3. Developmental students can overcome their deficiencies when given the opportunity and time to learn. (Hardin, 1988, p. 2)

Most of the research that has been done seems to support these statements. If educators accept them and believe that a high percentage of these students can turn their academic lives around, then it is unconscionable to systematically exclude them from higher education. To do so makes no sense economically as some would suggest, and would deny much of the philosophical freedoms held so dear in this country.

The goal of future research should be to determine the keys that successful programs have in common, and to find ways in which those keys can be easily replicated by other programs striving for success. Some of these are straightforward. Mickler & Chapel (1989) and McDonald (1988) complain that adjunct faculty members are being stuck or saddled with the remedial classes. They point out that the most experienced faculty rarely volunteer for remedial classes and some [illegible] are automatically rotated. This situation tends to lend itself to a high burnout rate even among those faculty dedicated enough to teach remedial courses over an extended period of time. McDonald (1988) found that one-third of remedial classes in the two-year colleges had student:faculty ratios of 40:1 or higher; many were in excess of 50:1. Ansley (1991) found that over half of remedial classes were taught by part-time faculty. Few would argue that schools need to lower student:faculty ratios, provide qualified and capable instructors, try to remove the stigma of being assigned to a remedial class (for both students and instructors), and to otherwise improve instruction as much as possible. Issues on how to identify students for remedial classes and how to insure said students receive the necessary assistance, however, are not without controversy.

Issues of Placement and Testing

Remedial education has been the gateway through which many deserving yet unprepared students have gone on to both personal and academic success. Yet, "unless we can determine the readiness of students who enter our community colleges for college learning, we cannot continue to claim to be open door institutions. Programmed failure for the high risk students makes the open door a cruel irony" (Rouche and Archer, 1979, p. 26). Accurate assessment and placement are keys in any remedial education program. "Appropriate placement has been shown to significantly increase the student's retention rate, skill growth, and GPA" (Cox, 1985, p. 19). Institutions can have the best equipment, instructors, tutors, and resources in the educational world, but if students are not matched with the appropriate level of instruction, very little has been accomplished. "Placement is one of the pillars on which a developmental program rests. This is particularly true in mathematics with its hierarchical and carefully delineated course content" (Akst and Hirsch, 1991, p. 3).

While most educators would philosophically agree on the necessity of identifying and supplying the correct level of instruction needed by each student, there is less than a consensus on how to accomplish this. By and large, institutions attempt to achieve this aim at least in part by testing, and in truth most use testing as the sole basis for placement. Lederman et al. (1985) found that only 15% of institutions used other criteria for placement in addition to or instead of a placement test. Many testing proponents agree with Morante (1989, p. 2) who argues that any data other than test data is "unreliable, insufficient, or nonexistent."

Still many others like Wambach and Brothen (1990) continue to advocate including alternate measures. Wattenbarger and McLeod (1989, p. 17) also "recommend multiple measurements and sources of data about an individual student." "There is ample reason for concern about such a direction: life-changing decisions should not be made on the basis of a single test score" (Rounds and Anderson, 1985, p. 25). "It is interesting as well as important to note that even those organizations that publish and distribute standardized college-entrance examinations do not advocate their use as the sole means of evaluation and placement." (Wattenbarger and

McLeod, 1989, p. 18). Miles (1993) also argues that with multiple assessments all purporting to measure the same phenomenon and depicting the same result, educators and students can be more confident in their findings. Even Morante, a strong advocate of placement tests, believes educators should "never use one score on one test as the sole factor in making placement decisions" (1989, p. 3). Other researchers (e.g. Rounds and Anderson, 1986; Weber and Twing, 1986) have made the same recommendation. Furthermore, most testing advocates also agree that one should "never set up dichotomous cut-scores in making placement decisions" (Morante, 1989, p. 3). "In any assessment/placement process there is always a need for flexibility in dealing with students" (Haase and Caffrey, 1984, p. 5).

Many educators believe that once a student has been identified as having severe deficiencies, s/he will voluntarily submit to the appropriate remediation in order to overcome it. "A voluntary program assumes that students are motivated to improve their skills and will choose to do so" (Maxwell, 1979, p. 31). However, "hoping that merely advising students to take the kinds of courses in which they have done poorly in the past will be sufficient may be unrealistic" (Rounds and Anderson, 1985, p. 24). "Those most in need of academic support services will not volunteer; in fact, they will avoid services planned to help them" Maxwell (1979, p. 23).

Rounds and Anderson (1985, p. 23) found "considerable evidence that students who most need remedial assistance will resist it." As an example they cite a study from Sacramento College, which instituted a student advising system but found that counseling did not tend to increase enrollment in remedial classes. Other studies further document the problem. Conlin (1989) found that 30% of remedial students registered for the incorrect course or failed to register at all. Haase and Caffrey (1984) found that 23.7% of students never took the courses they were advised to take.

Conlin (1989) and others have indicated that the problem of avoidance is much worse for mathematics than remedial classes in general; that is, math classes are the most frequently avoided classes among all types of remedial classes. Conlin (1989) reported that 61% of the recommended classes skipped by remedial students were math classes. There were far more math classes skipped than all other remedial classes combined! Plisko and Stern (1985) found that only 32% of students who were advised to enrolled in remedial math classes did so. Sworder (1990) found that of those remedial students who registered for a class, 36% registered for a higher class while only 2% registered for a lower one. Sturtz and McCarroll (1993) found 28.5% of remedial students had never enrolled in any math class and 7% had enrolled in a higher class than recommended. Rounds and Anderson (1985) reported that at Bronx Community College, only 29% advised to take remedial math did so. Rouche and Snow (1977, p. 8) reported that "as many as 90% of all students assigned, advised, or counseled into remedial courses never completed them."

The high incidence of skipping remedial mathematics has caused many researchers to investigate the consequences. Gabe (1989) found that only one-third of skippers (those who bypass needed remediation) pass college-level classes. Morris (1982) found that students who showed a need for remediation in one to three skill areas were more likely to return the next term if their course work had included developmental courses. Bypassing remedial math classes seems to have a devastating effect on later attempts to pass curriculum-level math. Haase and Caffrey (1984) found that students who availed themselves of the established assessment, advisement, and placement had retention rates ranging between 61-77% while those who did not had ranges of retention between 44-66%. Gabe (1989), in a study at Broward Community College, recorded that 46% of those who took remediation passed college algebra while only 25% of those who avoided it did. Conlin (1989) found that among those students who avoided recommended remediation, 70% failed their first college-level math class and another 20% withdrew. For those students who completed all their remedial math, their combined GPA in their first college-level math course was 2.58; for the group completing at least half of their recommended remediation, the GPA was 2.28; for those students completing less than half, the GPA was 2.02; and for those who skipped it entirely, the GPA was 1.82.

Since "the consequences of misplacement can be devastating for the student, especially in mathematics" (Akst & Hirsch, 1991, p. 3), many educators have begun to insist upon mandatory placement policies. Grable (1988), Morante (1989), Rouche & Baker (1987b), and Ansley (1991) are but a few of the educators who advise schools to adopt a mandatory placement policy. Here are some examples:

> A comprehensive developmental education program must include mandatory assessment and mandatory placement. Testing must be mandatory because too many students, especially those who most need assistance, will avoid assessment whenever possible. Placement must be mandatory since it borders on the unethical to know that a student lacks basic skills but is still allowed to enroll in college courses requiring that skill. (Morante, 1989, p. 2)

> To be most effective, participation in academic support programs should be mandatory, closely monitored and tied directly to specific credit courses. (Rogers and Steinhoff, 1991, p. 37)

> Self-placement of students into classes is not sound policy. It is a wasteful inefficient use of resources...A substantial number of students fail because of placing themselves at academic levels inappropriate to their present skill levels. (Cox, 1985, p. 4)

> An institution that has identified a student as academically deficient and enrolled the student has an ethical responsibility to help the student overcome his deficiencies- not to simply allow students to

> take their chances in the regular college-level curriculum. (Ansley, 1991, p. 28)

> Washington State Student Services Commission took the position that an institution which allows or advises academically underprepared students to enter college-level courses is effectively closing the door to their success. (Akst and Hirsch, 1991, p. 3)

The results from various studies seem to indicate that mandatory placement policies have a positive impact. Mickler and Chapel (1989) found that when a program of mandatory placement was put into effect at Miami-Dade, retention among black students increased from 32% to 48% (a 50% increase), and there was no decline in enrollment. Students involved in the program were nine times more likely to graduate than those students who were not! Borst (1984) found that after a skills prerequisite system that included mandatory placement was put in place at Fullerton College, the drop rate fell from 38% to 21%. Those completing remediation also had higher GPA's and took 2.5 times as many courses the following year.

In spite of the evidence of the success of mandatory placement programs, approximately one out of every three two-year colleges does not yet have one in place (Ansley, 1991), and there are a few educators who are vehemently opposed to them. Many continue to argue for a student's right to fail, and that "students should be *guided* to learning situations" (Bray, 1987, p. 40). Dodson generally admits that mandatory programs work but is still an advocate against them. Even though "it is generally to the student's advantage if the recommended remediation is completed, we must be willing to allow the student the luxury of failing a course if he is not willing to accept guidance" (Dodson, 1987, p. 59). However, given the current climate politically and the pressures the public is putting on education to be accountable, there is little doubt that the number of mandatory programs will continue to grow in the near future.

Issues in Choosing a Placement Test

While many educators would agree philosophically that programs requiring testing and appropriate placement are laudable, most would also agree that the current state of testing and placement has yet to reach a high level of sophistication and success. If it had, there would be far more widespread agreement on policies, procedures, and even the appropriateness of the various tests being used. Ansley (1991) found that the institutions in the SREB region alone currently use 125 different combinations of 75 different tests in testing students in reading, writing, and mathematics. In mathematics, the *in-house* or *institutionally developed* test was the most common choice, with 24.7% of institutions using a test of their own making. It is worth noting, however, that even though this is identified as a single choice, in truth there are as many versions of these tests as there are institutions, with no evidence of any relation among these various institutional tests. Other researchers have determined that the in-house test is particularly popular in two-year colleges (Lederman et al., 1985; Grable, 1988; Morante, 1989; Rouche et al., 1987), estimating its usage at about half of the two-year institutions nationally.

Another common practice is to use the students' ACT or SAT scores in determining placement, although this was never what the test was intended for (Wiener, 1989; McDonald, 1989). Studies have shown that neither the SAT or ACT is a very accurate predictive tool. Wattenbarger and McLeod (1989, p. 18) correlated scores from just the math portion of the SAT and ACT "with grades earned in eight different entry-level mathematics courses, ranging from basic math skills to first-year calculus." Correlations of test scores and grades were found to be low; almost half were negative. In spite of such results, Ansley (1991) found that approximately one-third of the colleges in the SREB states were using these tests and other researchers (notably Wiener, 1989; McDonald, 1989; and McDonald 1988) have found similar results for other regions of the country.

There are of course a wide selection of standardized tests from which to choose; of these the ASSET Test seems to have a small edge over its nearest competitors, at least in the number of institutions which utilize it. Ansley (1991) found the ASSET Test to be the most frequently used standardized placement test among two-year colleges across the SREB region, with MAPS and AAPP tests being mentioned less predominately and with more of a regional bias. Grable (1988) also cites ASSET as the most predominately used placement test in the Texas community colleges, with a significant portion using the MAPS DTMS test.

Virtually every college at some point has had to make the decision about whether or not to use a standardized test for course placement. In an environment with either hostile or at least cautious individuals, a standardized test is the easy choice. It is something others have used, so it gives faculty access to normed scoring data, access to national statistics in many cases, and a wealth of knowledge and experience to draw from in making placement decisions. It is also less work for the faculty. It can be graded right on the premises in most cases now, and in some cases can even give the students instantaneous feedback.

Yet standardized tests are not without major pitfalls. Consider first that no matter what test an institution uses,

> the foundation for a mathematics assessment program should be the goals of the program, and these goals must be selected in the context of curricular and institutional needs... [and therefore] ...the test should be designed to reflect an institution's current course and curriculum with well defined skill requirements. (McDonald, 1989, p. 20)

Wiener (1989, p. 25) states the same issue somewhat differently: "The testing program must relate to the curriculum as it is defined and reviewed by faculty, and it must suit the institution's mission and the needs of its students." In a more cynical manner, Miles (1993, p. 36) reaches a similar conclusion in quoting "Binet's amendment to Murphy's Law...you'll never find a standardized test which fully matches all that you are trying to accomplish, no matter how little you are trying to accomplish". An advocate of standardized tests himself, Miles readily admits this shortcoming as well as the more mundane problems, such as higher costs and longer time commitments for students, that come with standardized tests.

If these shortcomings were not enough to fuel the arguments of detractors of standardized tests, recent studies have shown many standardized tests to be less than the strong predictors their advocates had hoped for. Jones (1991), Jones (1993), and Hughes and Nelson (1991) have all shown the ASSET Test, probably the foremost placement tool in two-year colleges, to have some serious weaknesses. In neither of Jones' studies did he find higher than a .42 correlation between ASSET and actual classroom performance in any entry-level mathematics course taught at Hocking College. Both studies show the ASSET Test is of little help for assisting with the placement of borderline students. Jones (1991) found that for students scoring between 35-40 points, the ASSET did no better at placement than random chance would be expected to do. Jones (1993) conducted a study in which students were placed into three tiers based on ability levels. In the middle ability level group, the correlation was found to be only .003.

Finally, the American College Testing Program (or ACT), which publishes the ASSET Test, found a correlation of .34 between the ASSET Test and scores of students in introductory algebra classes across 15 college campuses (ACT, 1994). They also reported that any cut-score introduced into a beginning algebra course would actually result in a lower prediction success rate (where success equaled a grade of C or higher) than the existing success rate (i.e. no placement at all). For instance, one report found that 73% of all students pass their beginning algebra course with a grade of C or higher. If one merely placed all these students into a beginning algebra course, 73% would have been placed correctly as evidenced by their successful completion. The higher the cut-score introduced, the lower the prediction success rate. Introducing a cut-score of even 36 (lower than any school in their studies actually used) would result in only 66% being placed accurately (the highest prediction success rate reported in the study). However, ACT reports that the median cutoff used nationally is 44. Two different reports (ACT, 1994) suggest that using this cutoff results in correct placement decisions less than 50% of the time. In other words, a coin flip would be more effective in deciding the placement of these students.

Isonio (1992) found similar results with the MDTP Test (Math Diagnostic Testing Project). With regard to possible entry-level courses, the MDTP had predictive validities generally between r=.30 and r=.49, depending on the class, with an overall median of r=.37 for all courses. College of the Canyons (1994) found that the Algebra Readiness Test (one section of the MDTP Test) had a correlation of r=.42 when compared with final grades in an entry level algebra course. The same study found that the Intermediate Algebra Test (another section of the MDTP Test) was not an "appropriate test for any of the mathematics courses studied." In fact some correlations between [illegible] and final grades were actually negative.

McDonald (1988) and Lederman, et al. (1985) correctly point out, however, that an in-house test is no guarantee of a valid test with a high degree of predicative value. They complain that local tests have undergone little academic review or validation, and that even when such research attempts did occur, researchers often employed antiquated procedures and research components. Ebel and Frisbie (1991) drew similar conclusions. They have shown that the reliability of in-house tests is usually low and that too often local tests undergo no validation procedures whatsoever. Finally, they argue that rarely is there more than the most meager attempt to link the test with the curriculum.

Summary

While little consensus exists over issues of placement and testing, the one point on which all educators agree is that the lingering debate will continue on for some time. It is a complicated issue to say the least, an issue with political, philosophical, social, moral, and economic repercussions. It is an issue which can be argued on many levels. What is clear is that remedial education is not likely to disappear in the near future. Educators need to concentrate on improving the system as much as possible. Students in remedial programs need assurance that they are receiving the best and most appropriate education possible. They also need to know that they are receiving the assistance they most need; assistance which insures, among other things, that each student is given the opportunity to fill in the gaps in his/her mathematical foundation. An essential component of that education is identifying where those gaps exist. To date, placement tests, used in combination with other data and assistance from a solid advising program, are the most practical means for obtaining the information the student needs to be successful. Research in remedial education must focus on improving the quality of the educational experience the student receives and identifying ways to determine what educational experiences are most appropriate and most needed by each individual student.

CHAPTER THREE

Methodology

The Population

During the Spring of 1996, a letter was sent to all academic vice presidents as well as at least one person associated with the math program at each of the nine two-year technical colleges in Ohio to determine the interest in the project (the letter and interest survey are included in Appendix A). Two-year colleges were chosen because in Ohio they are increasingly being charged with remediation in mathematics. It was also felt that by limiting participation to only technical colleges, the sample for study would be more cohesive. Of the nine technical colleges in Ohio, six elected to participate. Five of these schools participated during the Summer term of 1996, and one of these also agreed to participate during the Spring term of 1996 (Technical College #1). One institution elected to participate only during the Fall quarter (Technical College #3). At all these institutions, a placement test (the AAT) was given in all entry-level algebra classes of those instructors who agreed to participate.

The test was given to a total of 415 students who were enrolled in entry-level algebra courses. These courses were part of the regular curriculum on the campuses of two-year technical colleges in the state of Ohio. In general, the topics taught in these courses included: solving and graphing linear equations, factoring, operations on algebraic expressions, rational expressions, simplifying radicals, and systems of linear equations

Student participation was encouraged but was strictly voluntary (a consent form is included in Appendix A). All but one student agreed to participate. Although each student was given the option of obtaining his/her results, none elected to do so. Complete anonymity was maintained. The researcher knew the students only by code numbers, and although instructors knew each student's code number, they did not know the results of the test. All of the methods were reviewed and accepted by Ohio University's Institutional Review Board. (A copy of the letter of approval is contained in the appendix).

The Instrument

The Arithmetic Achievement Test (AAT) was designed for the placement of students into the mathematics curriculum of two-year technical colleges. (The actual test is included in Appendix A). It was first given to arithmetic students at Hocking College during the Summer of 1993. It is a series of 25 multiple-choice items with 5 possible solutions to each answer; most having "none of the above" as a possible solution to discourage attempts at merely recognizing or guessing the correct solution. The original set of questions was designed by the author. The questions on the original instrument were designed to test students' knowledge on arithmetic. The concepts tested came directly from the curriculum. The goal was to develop a set of questions that would test the most critical aspects of arithmetic which were needed for success in an entry-level algebra course. Once developed, the test was distributed among the other seven members of the mathematics department at Hocking College. On the basis of suggestions from this advisory group, some questions were altered, others deleted, and some new questions added. All eight members then met together to fine tune the final instrument which was eventually tested. In this latter meeting, only minor adjustments in the wording of some questions were made.

The test was given in all entry level mathematics during the Summer of 1994. Using the Pearson Product Moment Correlation, it was found that correlation between the test and the actual final grades of students enrolled in a remedial class (titled Basic Mathematics) was r=.44 for the 17 students enrolled. The correlation between the test and the actual final grades of 30 students enrolled in Pre-Algebra was r=.64. The remedial course covered basic operations on fractions, decimals, and percents, in addition to order of operations and applications in all these areas. The pre-algebra course covered the Metric System, signed numbers, powers, roots, and percents, with a concentration on order of operations and applications to all these topics.

A second study was conducted during the Spring of 1994. In this study, an introductory-level algebra (College Algebra I) course was included in addition to the Basic Mathematics and Pre-Algebra courses described above. This course covered the Metric System and conversions to and from the English System of measurement, simplification of algebraic expressions, solving linear equations, functions, and graphing. There was an emphasis on applications in this course. The correlation coefficients when pairing AAT scores to final grades, were r=.44 (n=28), r=.50 (n=59), and r=.37 (n=83) for Basic Mathematics, Pre-Algebra, and College Algebra I respectively. A total of 260 students were included in the study, including 69 who dropped the course and whose numbers were not included in the correlation factors. In the College Algebra I group, there were 8 outliers whose final scores were a dramatic departure from expected outcomes. If these subjects are deleted from the study, the correlation factor rises to r=.52.

Another study analyzing the AAT was conducted during the Fall quarter of 1994 using the same courses as described above. The Pearson Product Moment Correlation between the students' AAT scores and their final course grades were r=.23 (n=99), r=.34 (n=129), and r=.35 (n=111) for Basic Mathematics, Pre-Algebra, and College Algebra I respectively. Once again if outliers are deleted from each of these groups, the correlation coefficients rise to r=.41, r=.47, and r=.50 respectively.

During Winter quarter of 1996, an item analysis similar to that described by Ebel and Frisbie (1991) was conducted to determine which questions best separated students into groups of successes and failures. Those questions which were answered correctly more than 80% of the time or less than 40% of the time were eliminated from the study. The reasoning was that these questions did not help differentiate students into groups, since either most people got the question right, or the percentage of correct answers was little better than chance.

Next, a correlational analysis was done where every answer was assigned a 1 if it was a *hit*, or a 0 if not. If a question was missed by someone who was not successful, that was considered a hit. Likewise a person correctly answering the question and passing the course was also considered a hit. In both of these cases the question had accomplished its desired purpose- correctly predicting a student's failure or success on the basis of that one question. These scores were then correlated with the student's final grade in the course. In addition, each question was analyzed as to its effectiveness. Those questions with a correlation coefficient under r=.15 and a successful hit rate of under 60% were eliminated from the study. Additional questions were then designed similar to those which were not eliminated.

The end result was an instrument that tested students knowledge on the addition and subtraction of fractions and whole numbers, comparing fractional quantities (greater than or less than), the order of operations on integers, powers, roots, algebraic formulas, and applications involving percents. The test itself is included in the Appendix.

Data Collection

The test was given during the Spring of 1996 at one technical college (Technical College #1), during the Summer of 1996 at five technical colleges (all but Technical College #3), and at one college during Fall of 1996 (Technical College #3). A coordinating instructor was identified at each of the participating colleges. In most cases this was the original contact person in the math department to whom the initial introductory letter was sent, although in some cases a different person was identified for various reasons. These instructors were charged with disseminating and collecting tests, data sheets, etc. They also insured that each instructor was clear on procedural issues and communicated with the author as necessary for any clarification.

At least two weeks before the test was to be given, each of the coordinating instructors at each institution received: a test, answer sheet, and consent form for every participating student; directions for the proctors; a cover sheet for each class; and a cover letter briefly outlining the process (see Appendix A). In addition, a phone call was made to each institution's coordinator confirming the arrival of the materials, reviewing the procedures, and answering any questions the coordinating instructor might have. The test was given at each of the participating institutions and was proctored and administered by the classroom instructors at each individual institution at the beginning of the given term. All participants signed a slip indicating their willingness to participate in the study and were given the opportunity to decline participation.

Each participating instructor assigned each student a student ID number which consisted of his/her first initial and the last four digits of his/her Social Security number. These numbers were the only means the researcher had to identify students. These numbers were recorded on each individual's answer form. Test sheets, answer forms, permission slips, and cover forms were mailed by the coordinating instructors back to the researcher in a stamped self-addressed return envelope. The answer sheets were returned wrapped in the cover sheet identifying the instructor and course number and rubber banded. The results of these tests were never seen by any instructor other than the author, and no student ever requested to know his/her results.

The answer forms were read and graded using a Scantron machine, and the results, as well as the students' ID numbers, entered into a computer with other relevant data including the instructor's name, the institution, and the course number. Grade reporting sheets were sent back to the instructors at each institution. On these sheets, the students' ID numbers were listed in alphanumeric order. Instructors recorded final exam grades, final grades, and noted any student who did not finish the course. In addition each was requested to inform the researcher of the grading scale used in the course. These sheets were filled out at the end of the quarter or semester and returned to the researcher in a stamped self-addressed return envelope.

Data Analysis

All statistical calculations were performed using the SPSS statistical package and the spreadsheet package from Microsoft Works 3.0 for Macintosh. The correlational relationships were examined using the Pearson Product Moment Correlation Coefficient. The purpose of any placement test is to place students into courses. Using a process similar to that described in the ASSET Technical Manual (ACT, 1994), optimum cut-scores were developed. The researcher created a cut-score contingency table, an example of which is Table A1 in the appendix. Every possible score on the AAT was considered as a possible cut score. The score that resulted in the highest percentage of correct placements was then used as the optimal cut-score.

Using these optimal cut-scores, students were separated into two groups- those who would have been placed into the class, and those who would not have been placed. The cut-scores were first examined as rigid and inflexible, then also to allow for a small *grey zone*. As described by Morante (1989), the grey zone is an area where a student's score is not definitive- that is, the test does not clearly indicate that the student belongs to one group or the other. These optimal cut-score analyses were done across each course, across each individual institution, and across all courses and all institutions. Non-completers were eliminated from examination. The percentage of correct placements was compared to the standard of 67% set in this study, and also against the percentage of correct placements that would have taken place purely by chance. Cohen's Kappa was used to determined the percentage of possible increase over chance that was realized.

Determining the "grey zone" is frankly more art than science. In the ideal world, there is a magical line where every student who achieves that given score on his/her placement test passes the course, and all those below this line fail. Unfortunately, in the real world this very rarely happens. In most cases, what happens is that failure rates fall along a continuum.

Those students scoring the most poorly on the placement test have the highest failure rates in the course. As the placement scores increase, the failure rates decrease until among the highest achieving students the failure rate is very small. In determining the best grey zone, the researcher wants to isolate two groups- one group with low placement scores where the course success rate is very low, and the other with high placement scores where the success rate is very high. In general, the larger the disparity in success rates, the more effective the instrument.

If the only requirement was the large disparity in course performance between the low-scoring placement test group and the high-scoring placement test group, one would merely place those with the absolute lowest scores into one group and those with the absolute highest into another group and call everything in between the grey zone. The problem, of course, is that this would not be very useful, as most of the people tested would not be identified as falling into one group or the other. To be able to provide useful information to both students and advisors, balance is needed. As a general rule, the larger the grey zone, the larger the disparity will be between the two groups, and the converse is true as well. The researcher needs to keep the grey zone as small as possible while simultaneously insuring the difference between the groups is as large and therefore meaningful as possible.

In the present study, the grey zone was always kept in the range of two to four points. The results reported in this paper are only meant to give some reference to the reader as a possible grey zone. They represent the best balance that the researcher was able to establish. In general, any researcher looking at the individual data could create a different grey zone (by including either more scores or fewer) and have different degrees of success. However, no other grey zone of the same size chosen in each of the analyses in this paper would result in a better differentiation of students.

In many cases in this study, there were students who may have scored poorly on the AAT test and yet have done well in the course. Occasionally the reverse is true as well. As there was no incentive for the student to do well (other than perhaps an altruistic desire to assist in the research and the personal satisfaction derived from achieving a good score), there were no doubt many students who did not perform up to their abilities. The mathematical expectation of merely answering randomly on the AAT test is 5, yet many participants scored this low or even lower on the test. Among these students, some achieved some of the highest grades in their courses. Often those students scoring among the highest AAT scores would perform among the poorest in the class. The effect of these scores will occasionally be examined, but in all cases weakened the statistical analyses presented in this study.

The final grade was deemed the most important for the simple reason that it represents the single criterion by which each student will be judged a success or a failure. In addition to the final grade, the final exam score earned by each student was examined as well. This was done for two reasons. First, this score is seen as the best indicator of what a student has actually retained and his/her preparedness for the next class. Second, this score indicates actual overall performance at the end of the course and does not include such factors as attendance, participation, or homework completion that may have been included as part of the course grade and have little to do with the actual preparedness of the student.

Obviously many things other than preparedness for a course determine a student's final grade. For each individual student, obvious factors would include (among others): effort, learning style, attendance, high school GPA, age, number of years since the student was last enrolled in a formalized educational setting, and a virtually endless myriad of personal circumstances. This study includes only a correlational analysis of a single factor, however- preparedness for the course as measured by the AAT. Although other factors could have been included and multiple regression techniques applied, the decision to include only the AAT as an independent variable was made for two reasons. First, it seemed logical to examine this test on its own merits for comparison purposes with similar data on other tests. Second, on a more pragmatic level, placement based on a single such placement score is what commonly occurs at most two-year colleges.

Specifically, each hypothesis was tested as follows:

$H_0$1. A Pearson Product Moment Correlation Coefficient was calculated to find the strength of the relationship between the student's score on the AAT and his/her final grade in introductory algebra courses across all sections of the same institution. In cases where more than one introductory course was offered at a given institution, the strength of the relationship was first examined in relation to each individual course. Next, the strength of the relationship of the test was examined in relation to all courses offered at the given institution. A two-tailed z-test was performed using an alpha level of .05. Prior to performing this test, a Fisher r-to-Z' transformation was done.

$H_0$2. A Pearson Product Moment Correlation Coefficient was calculated to find the strength of the relationship between the student's score on the AAT and his/her final exam grade in introductory algebra courses across all sections in the same institution. In cases where more than one introductory course was offered at a given institution, the strength of the relationship was first examined in relation to each individual course. Next, the strength of the relationship of the test was examined in relation to all courses offered at the given institution. A two-tailed z-test was performed using an alpha level of .05. Prior to performing this test, a Fisher r-to-Z' transformation was done.

$H_0$3. A Pearson Product Moment Correlation Coefficient was calculated to find the strength of the relationship between the student's score on the AAT and his/her final grade in introductory algebra courses across all institutions. A two-tailed z-test was performed using an alpha level of .05. Prior to performing this test, a Fisher r-to-Z' transformation was done.

$H_0$4. A Pearson Product Moment Correlation Coefficient was calculated to find the strength of the relationship between the student's score on the AAT and his/her final exam grade in introductory algebra courses across all institutions. A two-tailed z-test was performed using an alpha level of .05. Prior to performing this test, a Fisher r-to-Z' transformation was done.

CHAPTER FOUR

Results and Discussion

In this section, the results from each individual institution will be reviewed first. Specifically, each analysis will include an examination of null hypotheses $H_0$1 and $H_0$2 which relate to the correlation of the AAT to the final grade and final exam grade. Each institutional analysis will also include an examination of how well the test performs when a single cut-score is chosen. In addition to a single cut-score, however, the analyses will include a discussion of a grey zone as well. Finally, at the end of the examination of each of the individual institutions, the overall results across all institutions will be examined, specifically hypotheses $H_0$3 and $H_0$4. These are exactly the same hypotheses examined at each individual institution but now applied to the entire data set. The overall analysis will also include an examination of cut-scores and grey zones. Finally, there will also be a discussion of how effective the AAT would be if it were to be adopted by each individual institution, and of the general effectiveness of the test across all institutions in the study.

Technical College #1

Descriptive Statistics

149 students participated in this study. Of these students, 45 (30%) dropped the course, 23 (15%) failed the course, and 81 (54%) successfully completed the course (see Table 1). These percentages are relatively typical of other technical colleges in the study. Of those completing the course, the mean grade was 77.9 with a standard deviation of 14.2, while the median was 80. On the final exam, the mean was 76.6 with a standard deviation of 16.8, while the median was 79.5. On the AAT, the mean grade was 12.7 with a standard deviation of 4.9, while the median was 13. These scores are relatively typical of other technical colleges in the study (see Table 2).

Table 1.

Raw Numbers and Percentage Rates of Students Passing, Failing, and Dropping Courses at All Institutions

Tech. Coll.	Passing	Failing	Drop	Total
#1	81 (54%)	23 (15%)	45 (30%)	149
#2	27 (53%)	12 (24%)	12 (24%)	51
#3	34 (56%)	11 (18%)	16 (26%)	61
#4	58 (75%)	8 (10%)	11 (14%)	77
#5	33 (59%)	4 (7%)	19 (34%)	56
#6	18 (86%)	0 (0%)	3 (14%)	21
All	251 (60%)	58 (14%)	106 (26%)	415

Table 2.

Median and Mean Scores on AAT, Final Exam, and Final Grade at Each Institution

	AAT		Final Exam		Final Grade	
School	Mean	Median	Mean	Median	Mean	Median
#1	12.7	13	76.6	79.5	77.9	80.0
#2	12.6	13	72.1	81.0	75.5	82.0
#3	11.6	10	75.0	74.0	83.6	84.0
#4	12.9	13	81.0	85.0	85.0	90.0
#5	18.5	19	77.6	81.5	82.7	84.0
#6	12.1	12	78.5	76.0	86.7	85.0
All	13.2	13	77.0	80.0	81.1	84

Correlational Analyses

The correlation of the AAT score to the final grade is r=.45. This result is not statistically different from r=.35 (z=1.206, p>.05), and therefore the null hypothesis can not be rejected. The correlation of the AAT score to the final exam grade is r=.44. This result is also not statistically different from r=.35 (z=1.075, p>.05) and one must again fail to reject the null hypothesis.

Optimal Cut-Score Analyses

Recall that 71% of completers and 54% of the students overall passed the course. If one merely predicted success in all cases, these would be the percentage of times that one would be correct (the existing success rates). Using optimal cut-scores, one can improve on both of these success rates (see Table 3). In both cases the optimal cut-score meets the minimum criteria of 67% for the separation of likely successes and failures as set forth in the study. Table 3 also contains information on the random percentage of correct predictions that would be expected to result from random assignment and Cohen's Kappa. Cohen's Kappa gives the percentage (in decimal form) of the students misplaced by chance which the test would correctly place. For example, if random assignment would result in correct predictions 60% of the time, then 40% of these students would be misplaced. If the test can improve this percentage to correct predictions 70% of the time, then this represents a 10% improvement when the maximum improvement was 40%. 10 out of 40 would be 25% or .25. Now consider using 10 as the optimal cut-score when considering only completers. Using the test correctly results in correct placements 78% of the time. However, chance accounts for 65% of those correctly placed, with 35% being misplaced. The test improves on this rate, recovering 13% of those 35% misplaced, or in other words recovering 37% of those misplaced by chance alone.

Table 3.

Optimal AAT Cut-Scores at Technical College #1

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	8	78%	69%	.28
	9	78%	66%	.35
	10	78%	65%	.37
All Participants	12	67%	51%	.33

The best *grey zone* for this institution seems to be the 12-14 point range (see Table 4). Those students whose AAT scores placed them above the grey zone (AAT>14) succeeded at a much higher rate than those below the grey zone (AAT<12). A student in the lower group was nearly three times as likely to drop or fail the course than the student in the upper group.

Table 4.

Success Rates for Technical College #1

AAT Score Range	Drop=Fail	Completers Only
<12	35%	56%
12-14	57%	87%
>14	78%	95%

Analysis of AAT's Potential as a Placement Test at this Institution

Technical College #1 had the largest group of students participating in the study. The AAT would seem to be an excellent placement instrument for this institution. There is a relatively strong correlation between performance on the AAT and both the final grade (see Figure 1) and the final exam grade (see Figure 2) that students received in the course. Statistically, neither of these correlations is significantly different than the standard of r=.35 as set forth in $H_0 1$ and $H_0 2$ of this study.

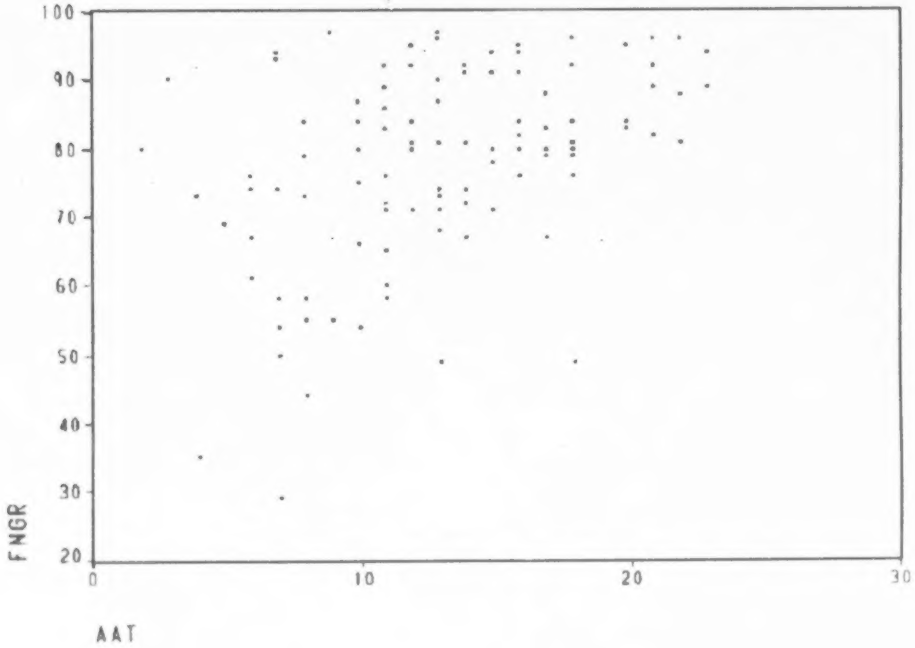

Figure 1. Scatter Graph of AAT Scores and Final Grades at Technical College #1.

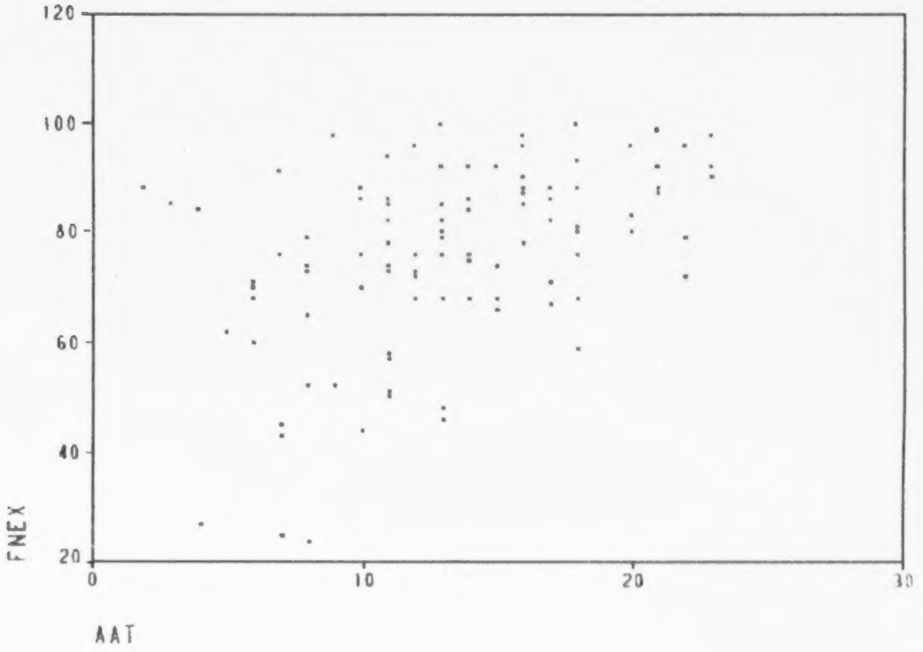

Figure 2. Scatter Graph of AAT Scores and Final Exam Grades at Technical College #1

There is a distinct rise in final grades as AAT scores increase (see Figure 3). There is a corresponding rise in the rates of success which can be seen when looking at completers alone (see Figure 4), and also when looking at all students and counting drops as failures (see Figure 5).

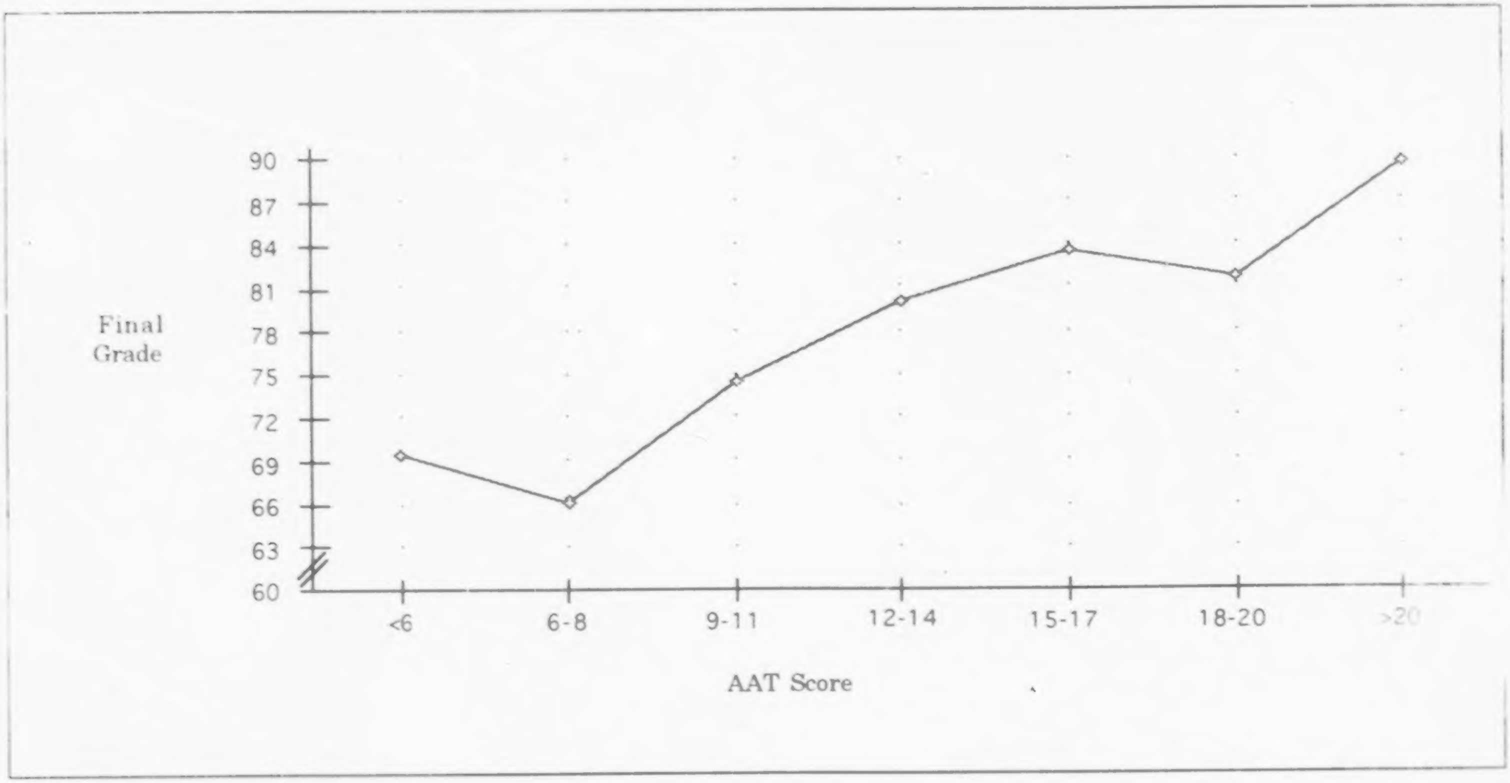

Figure 3. Mean Final Grades of Technical College #1 Students, Grouped by AAT Score.

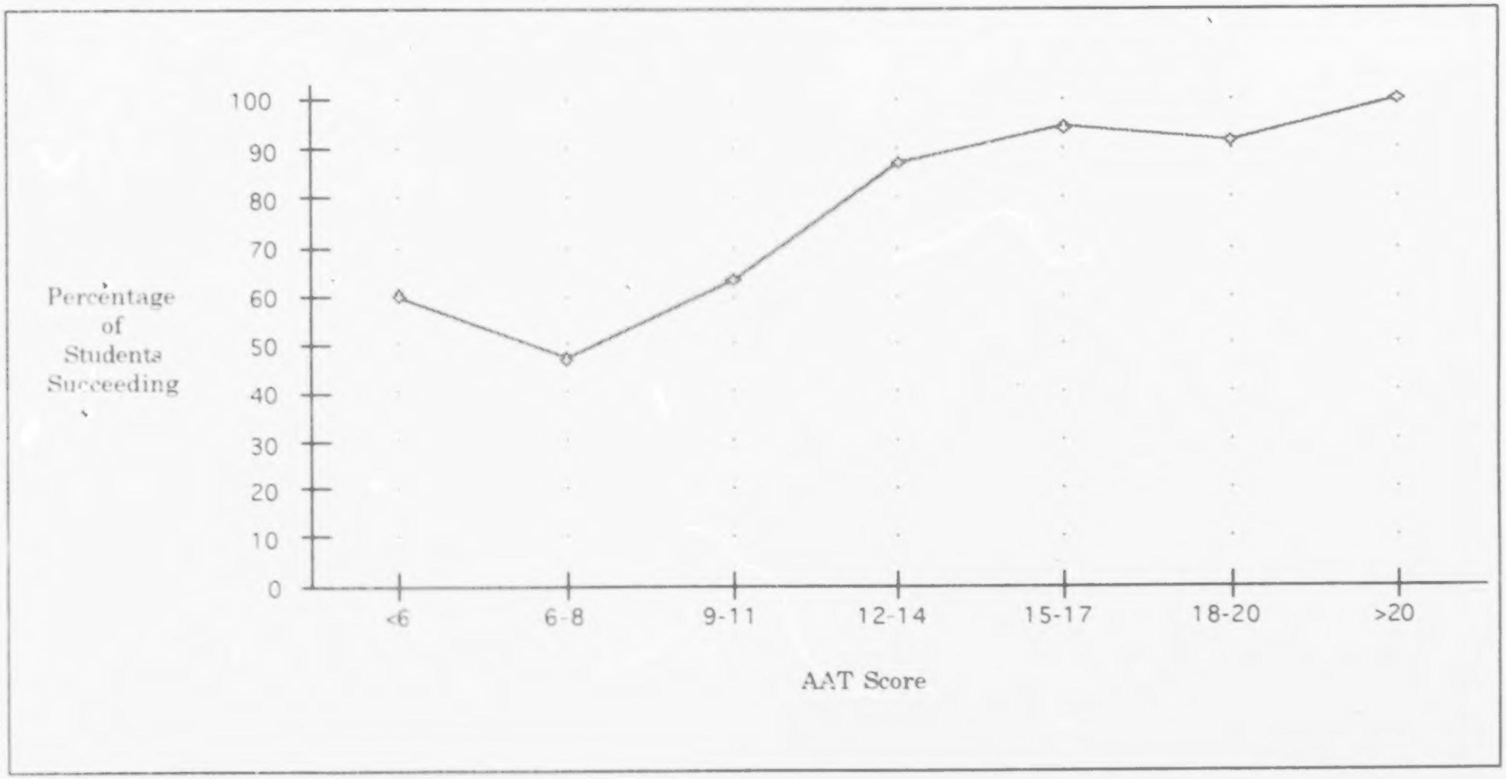

Figure 4. Percentage of Completers Passing at Technical College #1, Grouped by AAT Score

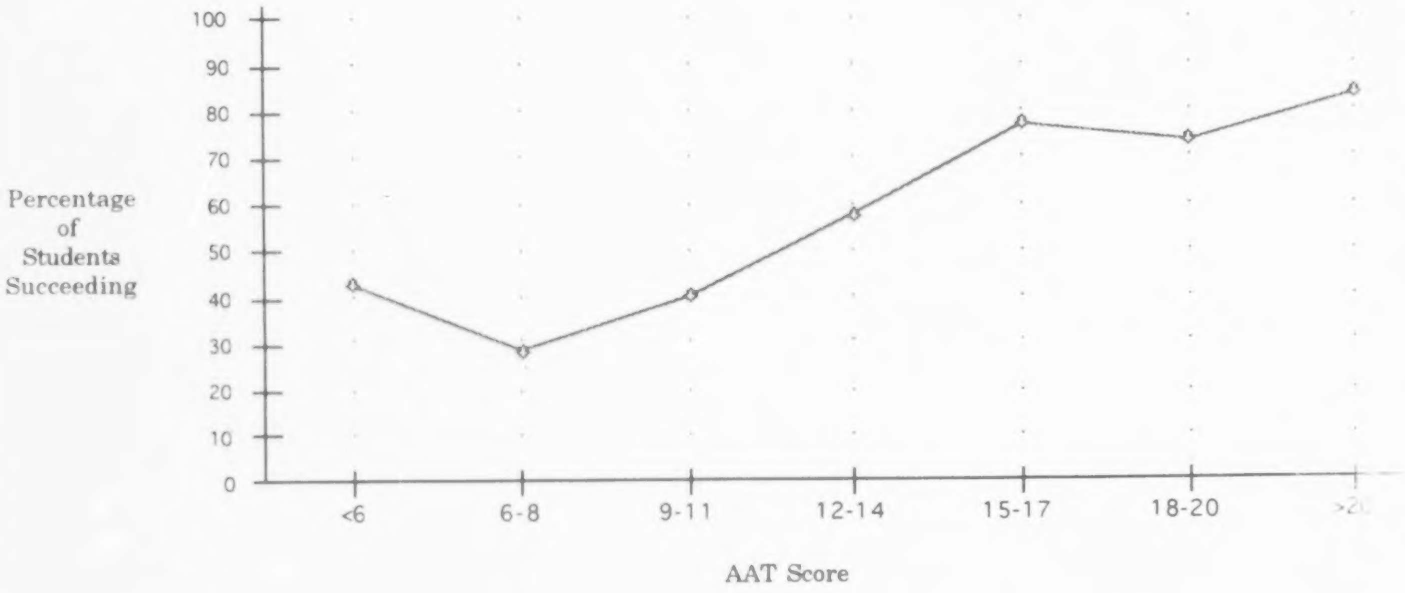

Figure 5. Percentage of All Students (Drop=Fail) Passing at Technical College #1, Grouped by AAT Score.

One interesting phenomenon on all of these graphs (Figures 3-5) is that grade averages dip when AAT scores increase from below 6 to 6-8. This appears to be a common phenomenon in studies of this type. The conclusion drawn, after seeing this phenomenon so frequently, is that a few talented students do not take the test seriously and get extremely low scores on the AAT. In turn they perform rather well in the course. The result is a *phantom tail*, or slight upswing in the lowest group, that is not truly representative of this group's performance. This was a group of students whose AAT scores were barely better than random guessing on the AAT, yet their final grades were higher than the best performers on the AAT test. Finally, the AAT does an admirable job of separating students into likely failures and likely successes (see Figure 6). The AAT meets all the criteria outlined in this paper for use as an effective placement instrument at this institution.

Technical College #2

Analysis of Introduction to Algebra (Math040)

Descriptive statistics.

19 students participated. There were 9 (47%) successful completions, 6 (32%) failures, and 4 (21%) drops. Of those completing the course, the mean grade was 69.1, with a standard deviation of 25.1, while the median was 81. On the final exam, the mean was 71.2 with a standard deviation of 26.0, while the median was 82. On the AAT the mean grade was 12.4 with a standard deviation of 4.9, while the median was 12. Although the failure rate is somewhat higher compared to other institutions in the study (see Table 1, p. 64), the remaining scores are relatively typical of the other technical colleges involved in the study.

Correlational analyses.

The correlation of the AAT score to the final grade is r=.52. This score is not statistically different from r=.35 (z=.731, p>.05), therefore the null hypothesis can not be rejected. The small sample size was no doubt a factor in the lack of a significant result. Even with a moderately sized sample of 65 students, a correlation of r=.52 (the same correlation found in this analysis) would have been statistically significant.

The correlation of the AAT score to the final exam grade was r=.53; again, this is not statistically different from r=.35 (z=0.779, p<.05). Therefore, the null hypothesis can not be rejected. Again, the small size of this sample played a crucial factor in the analysis. Even with a moderately sized sample of 90 students a correlation factor of r=.53 would have been significant.

Optimal cut-score analysis.

In this course at this institution, 60% of all completers and 47% of all students passed Introduction to Algebra (Math040). The introduction of cut-scores results in prediction success rates which are higher than both these existing success rates (see Table 5). Using the AAT and the optimal cut score makes a particularly substantial difference in the success rate when drops are counted as failures. In both cases (with and without drops) the optimal cut-score meets the minimum acceptable criteria of 67% correct predictions in the separation of likely successes and failures as set forth in this study. In all cases the placement rate of the AAT is distinctly higher than mere chance.

Table 5.

Optimal AAT Cut-Scores for Introduction to Algebra (Math040) at Technical College #2

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	8	73%	57%	.37
	14	73%	49%	.47
All Participants	14	74%	50%	.48
	16	74%	51%	.47
	17	74%	52%	.46

When looking at all scores, the optimal grey zone appears to be in the 13-15 point range. If this is used as the grey zone, the success rate for students above this range (AAT>15) is 83% among both completers and all students (drop=fail), as there were no drops in this score range. Students scoring less than 13 points on the AAT (students below the grey zone) have only a 43% success rate even among completers, and a success rate of only 33% when drops are counted as failures (see Table 6). When looking at all students (drop=fail), the failure rate for those below the grey zone is nearly four times as high as for those above the grey zone. Among completers, the failure rate is more than three times as high for those students below the grey zone as for those above.

Table 6.

Success Rates for Introduction to Algebra at Technical College #2

AAT Score Range	Drop=Fail	Completers Only
<13	33%	43%
13-15	25%	50%
>15	83%	83%

Analysis of AAT's potential as a placement test for Math040.

There were a very small number of students from this course participating in this study; the results would be more reliable had a larger sample been available. Even so, the AAT would seem to be an excellent placement instrument for this course in this institution. There is a relatively strong correlation between performance on the AAT and both the final grade (see Figure 7) and the final exam grade (see Figure 8) that students receive in the course. Statistically, neither of these correlations is significantly different than the standard of r=.35 as set forth in $H_0 1$ and $H_0 2$.

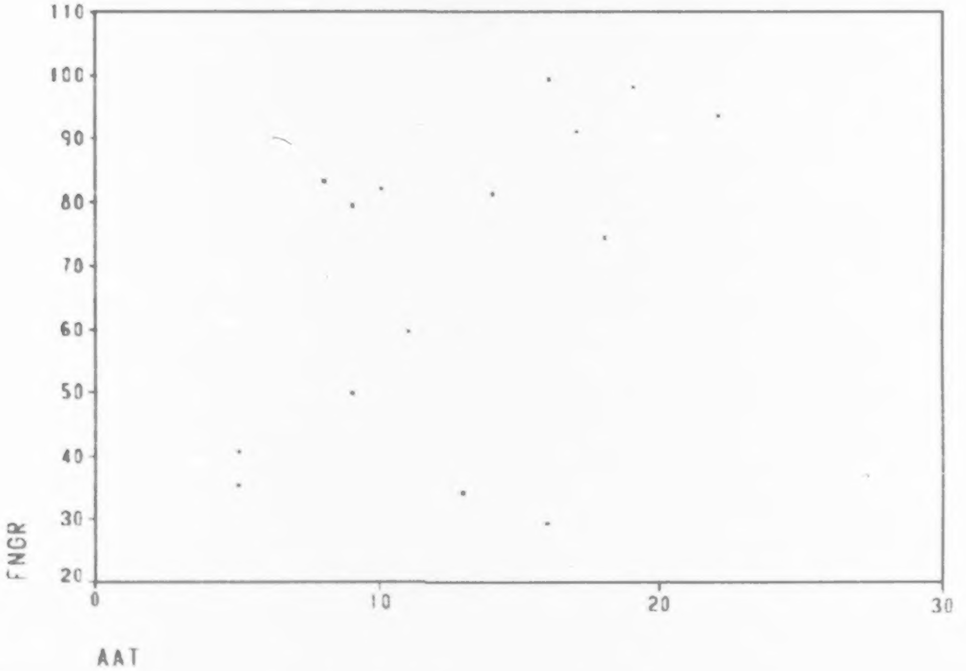

Figure 7. Scatter Graph of AAT Scores and Final Grades from Introduction to Algebra (Math040) at Technical College #2.

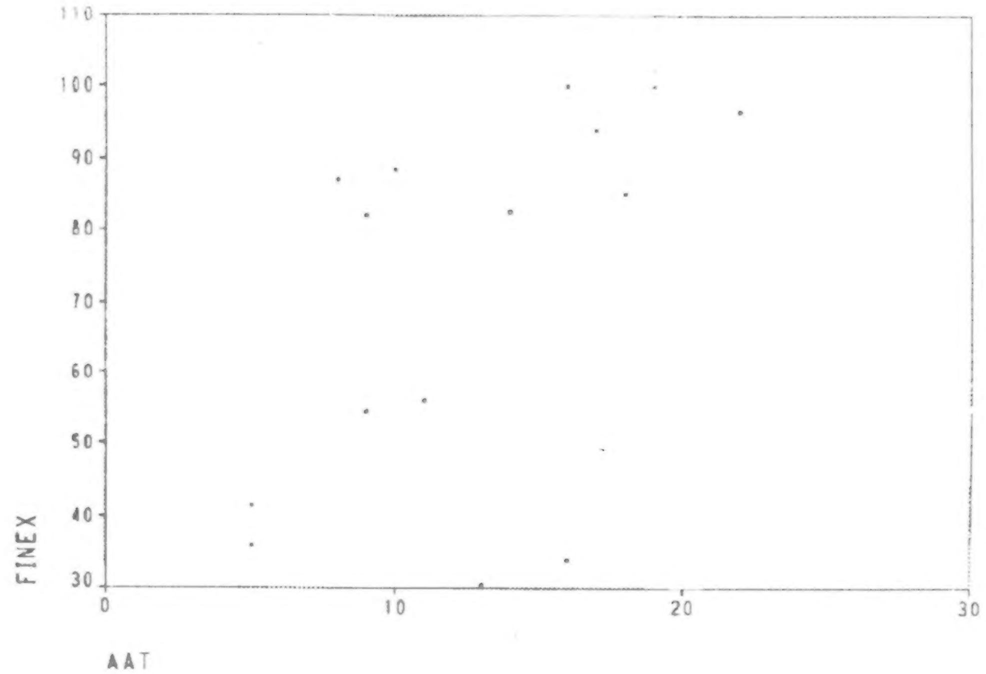

Figure 8. Scatter Graph of AAT Scores and Final Exam Grades from Introduction to Algebra (Math040) at Technical College #2.

There is a substantial rise in final grades corresponding to the rise in AAT scores (see Figure 9). The success rate, when drops are considered equivalent to failure, demonstrates the power of the test as well (see Figure 10). The test seems to be adequate in separating those students who will likely pass from those who will likely fail (see Figure 11). More testing would be required to fine tune the instrument, but the results from this small sample are very encouraging.

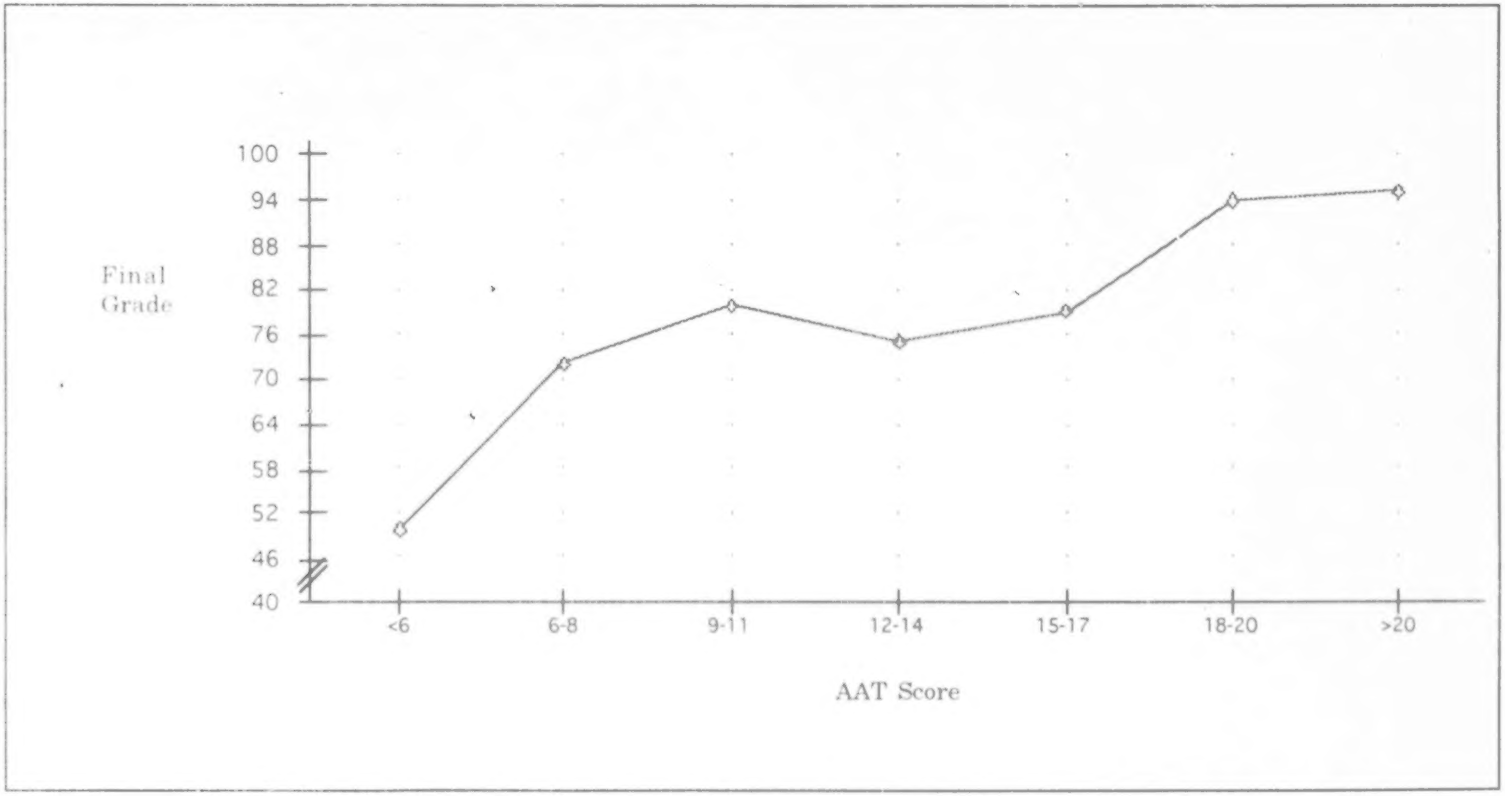

Figure 9. Median Final Grades of Technical College #2 Students in Introduction to Algebra (Math040).

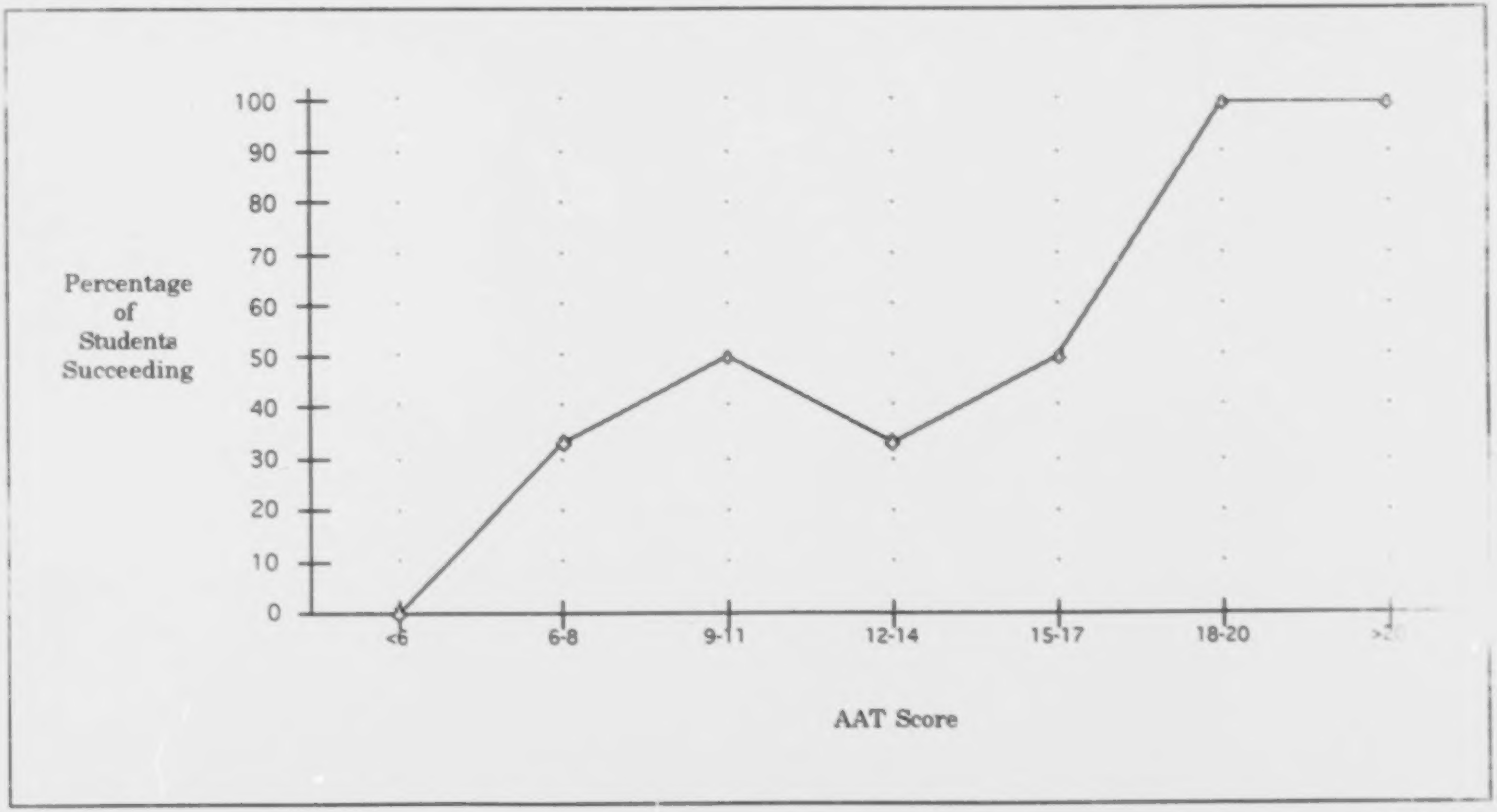

Figure 10. Percentage of All Students (Drop=Fail) Passing Introduction to Algebra (Math040) at Technical College #2, Grouped by AAT Score.

Analysis of Algebra (Math045)

Descriptive statistics.

32 students participated. There were 18 (56%) successful completions, 6 (19%) failures, and 8 (25%) drops. Of those completing the course, the mean grade was 79.5 with a standard deviation of 16.0, while the median was 85.5. On the final exam, the mean was 73.0 with a standard deviation of 22.2, while the median was 78.5. On the AAT, the mean grade was 12.4 with a standard deviation of 4.9, while the median was 12.5.

Correlational analyses.

The correlation of the AAT score to the final grade is r=.61.; this is not statistically different from r=.35 (z=1.576, p>.05). Therefore the null hypothesis can not be rejected. Once again, the lack of a significant result is due in large part to the small sample size. With even a relatively small sample of just 35 participants, a correlation score of r=.61 (the same found in this analysis) would be statistically significant.

The correlation of the AAT score to the final exam grade was r=.65. This score was not statistically different from r=.35 (z=1.879, p<.05), therefore the null hypothesis can not be rejected. The small sample size is again problematic. With just 1 more participant the given correlation would have been significant.

Optimal cut-score analysis.

The success rate among all students is 56%; among completers the success rate is 75%. The introduction of cut-scores substantially improves the prediction success rate in both categories (see Table 7). In both cases (with or without drops), the optimal cut-score more than meets the minimum acceptable criteria of 67% correct predictions in the separation of likely successes and failures as set forth in this study. In all cases the test's prediction success rate is substantially higher than can be accounted for by chance alone.

When looking at all scores, the optimal grey zone appears to be in the 9-12 point range. If this is used as the grey zone, the success rate for students above this range (AAT>12) is 93% among completers and 81% if drops are counted as failures. Students scoring less than 9 points on the AAT have a 0% success rate whether or not drops are included in the analysis, as all of these students below the grey zone (AAT<9) either dropped or failed (see Table 8).

Table 7.

Optimal AAT Cut-Scores in Algebra (Math045) at Technical College #2

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	8	88%	69%	.62
	9	88%	67%	.64
All Participants	11	78%	52%	.54
	14	78%	50%	.56

Table 8.

Success Rates for Algebra at Technical College #2

AAT Score Range	Drop=Fail	Completers Only
<9	0%	0%
9-12	50%	75%
>12	81%	93%

Analysis of AAT's potential as a placement test for Math045.

There were a very small number of students from this course participating in this study; the results would be more reliable had a larger sample been available. Even so, the AAT would seem to be an excellent placement instrument for this course in this institution. There is a relatively strong correlation between the performance on the AAT and both the final grades (see Figure 12) and the final exam grades (see Figure 13) that students receive in the course. There is a steady and substantial rise in final grades as AAT scores increase (see Figure 14). The success rate of students, when drops are considered equivalent to failures, demonstrates the power of the test as well (see Figure 15). The test also seems to be adequate in separating those students who will likely pass from those who will likely fail (see Figure 16). More testing would be required to fine tune the instrument, but the results from this small sample are very encouraging.

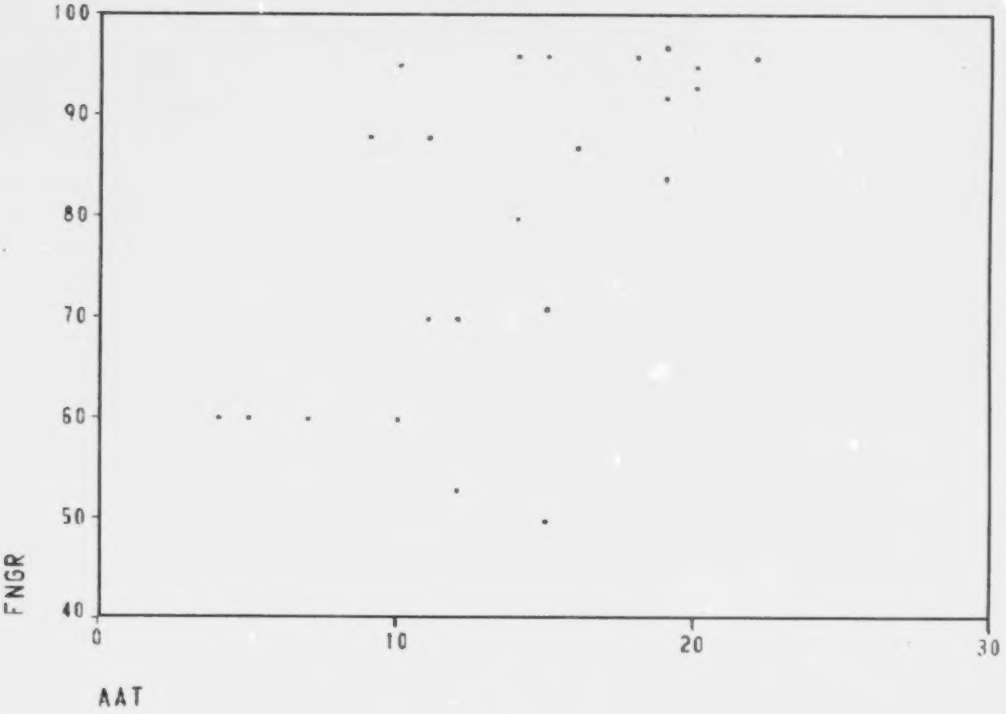

Figure 12. Scatter Graph of AAT Scores and Final Grades from Algebra (Math045) at Technical College #2.

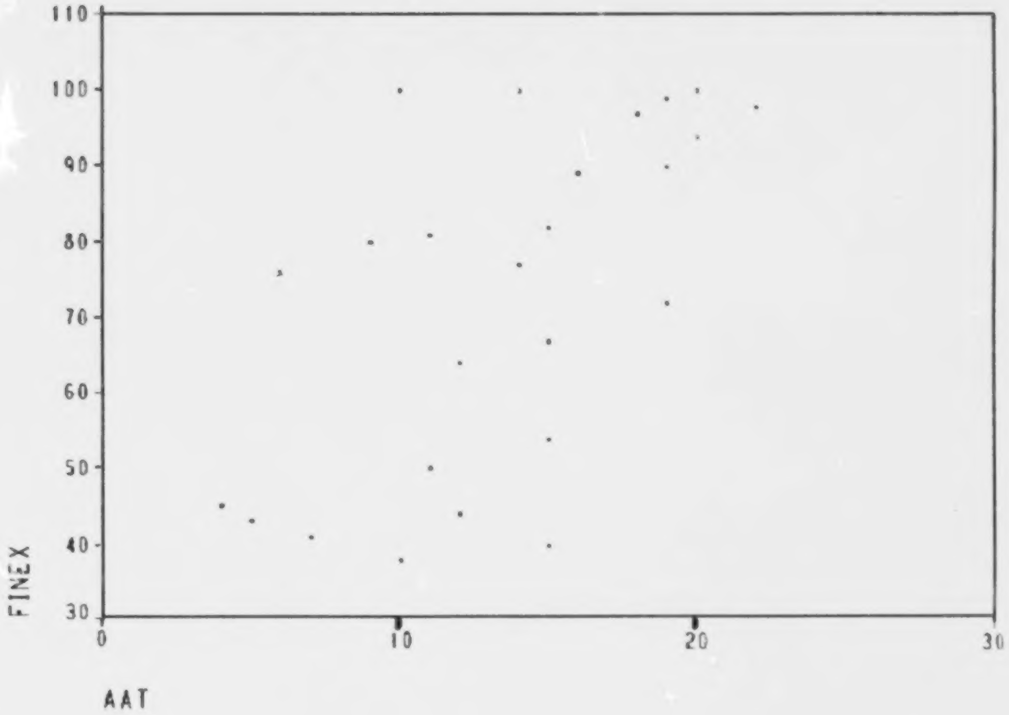

Figure 13. Scatter Graph of AAT Scores and Final Exam Grades from Algebra (Math045) at Technical College #2.

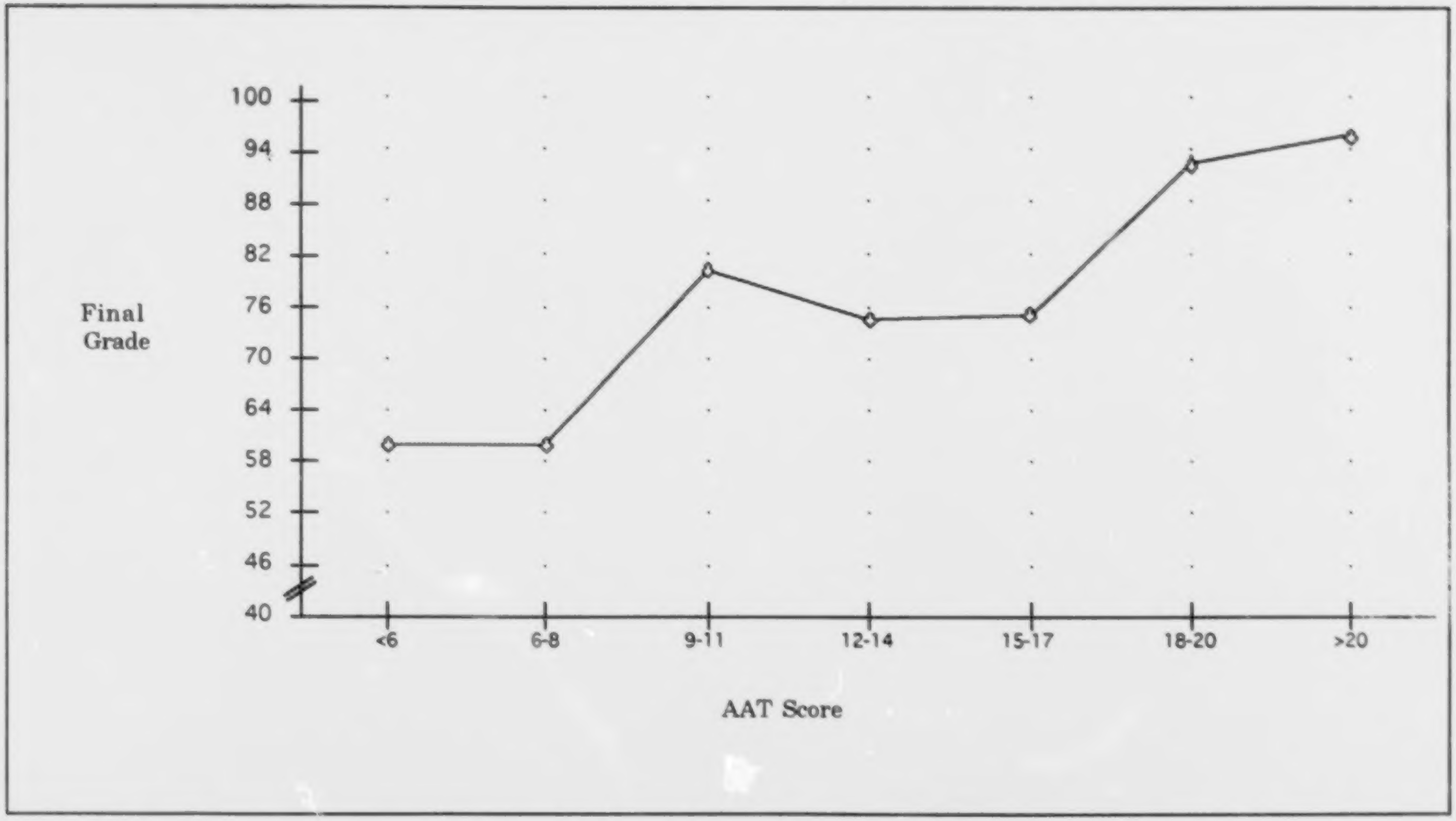

Figure 14. Mean Final Grades of Technical College #2 Students in Algebra (Math045).

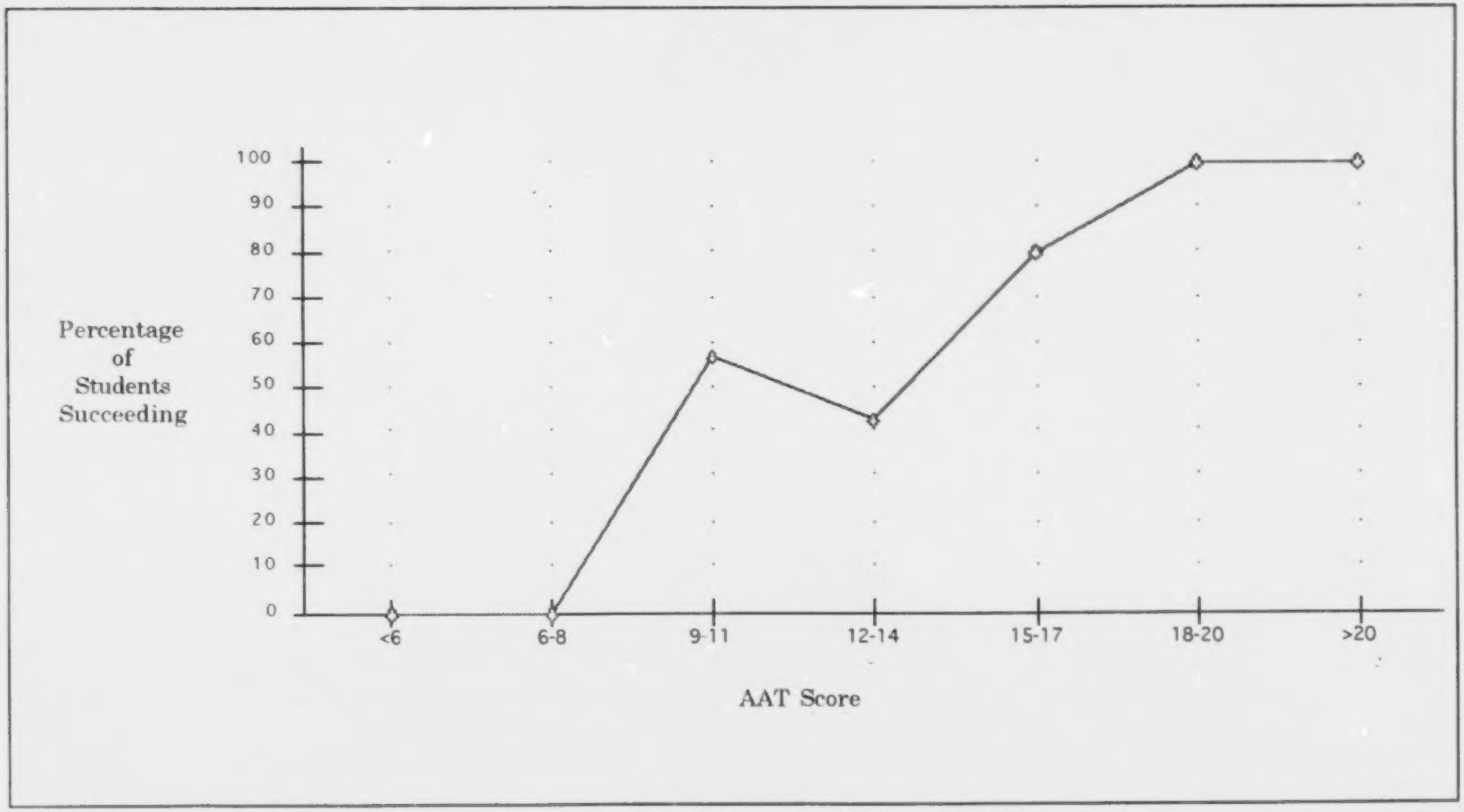

Figure 15. Percentage of All Students (Drop=Fail) Passing Algebra (Math045) at Technical College #2, Grouped by AAT Score.

Analysis Across Both Math040 and Math045

Descriptive statistics.

Using all students from both courses in this institution gives us a larger sample and therefore more reliable data. Between the two classes, a total of 51 students participated. There were 27 (53%) successful completions, 12 (24%) failures, and 12 (24%) drops. These figures are fairly representative of the other institutions in the study (see Table 1, p. 64). Of those completing the course, the mean grade was 75.5, with a standard deviation of 20.3, while the median was 82. On the final exam the mean was 72.1 with a standard deviation of 23.9, while the median was 81. On the AAT, the mean grade was 12.6 with a standard deviation of 4.8, while the median was 13. These scores are also representative of other institutions in the study (see Table 2, p. 65).

Correlational analyses.

The correlation of the AAT score to the final grade is $r=.56$; this is not statistically different from $r=.35$ ($z=1.608$, $p>.05$). Therefore the null hypothesis can not be rejected. Once again sample size played a large role in this analysis. Even a moderate sample size of 60 students (given the same effect size) would have been large enough to produce a significant result.

The correlation of the AAT score to the final exam grade was $r=.60$; this is statistically significant ($z=1.968$, $p<.05$). Therefore the null hypothesis is rejected.

Optimal cut-score analysis.

The rate of success at Technical College #2 is 69% among completers and 53% overall. The introduction of cut-scores can significantly improve on these prediction rates (see Table 9). In both cases, the optimal cut-score meets the minimum acceptable criteria of 67% as set forth in this study. Note also that in both cases the AAT performs substantially higher than chance operating alone.

Table 9.

Optimal AAT Cut-Scores at Technical College #2 (Both Courses)

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	8	82%	64%	.50
All Participants	14	76%	50%	.52

When looking at all scores, the optimal grey zone appears to be in the 11-13 point range. If this is used as the grey zone, the success rate for students above the grey zone (AAT>13) is 90% among completers and 83% if one counts drops as failures. Students scoring less than 11 points on the AAT (those students below the grey zone) and completing the course have a 42% success rate. If drops are counted as failures, the success rate in this group drops to 26% (see Table 10). The failure rate in the lower group is four times higher than that of the higher group when looking at all students, and nearly six times higher when considering only completers.

Table 10

Success Rates at Technical College #2 (Both Courses)

AAT Score Range	Drop=Fail	Completers Only
<11	26%	42%
11-13	33%	43%
>13	83%	90%

AAT's potential as a placement test at Technical College #2.

As was the case with each individual course, there is a relatively strong correlation between performance on the AAT and both the final grade (see Figure 17) and the final exam grade (see Figure 18) that students receive in the course. Final grades in the course rise steadily as the AAT scores increase (see Figure 19). The success rate of students when counting drops as equivalent to failures demonstrates the power of the test as well (see Figure 20). The test seems to do an excellent job of separating those students who will likely pass from those who will likely fail (see Figure 21). The test meets all the criteria for this institution as set forth in the study. While a larger sample would have been desirable, the results from this small sample are very encouraging.

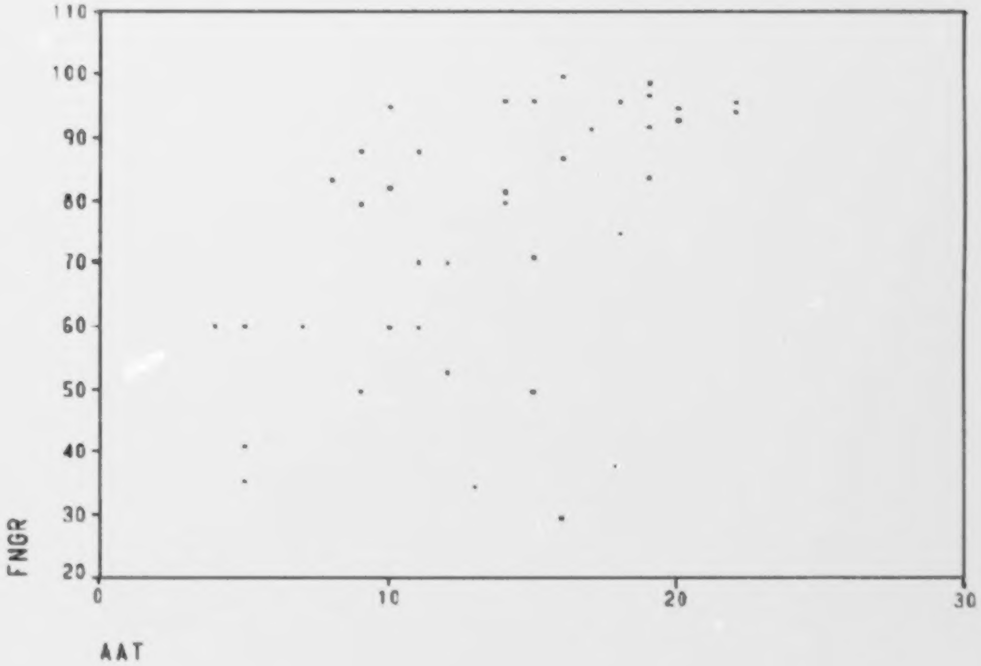

Figure 17. Scatter Graph of AAT Scores and Final Grades from Both Courses at Technical College #2.

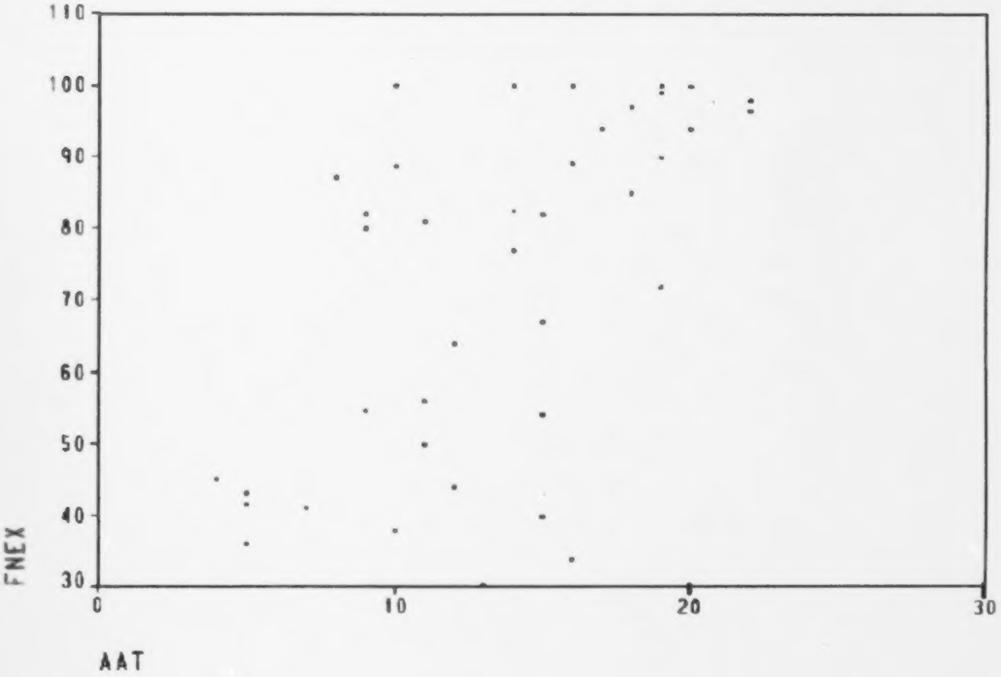

Figure 18. Scatter Graph of AAT Scores and Final Exam Grades from Both Courses at Technical College #2

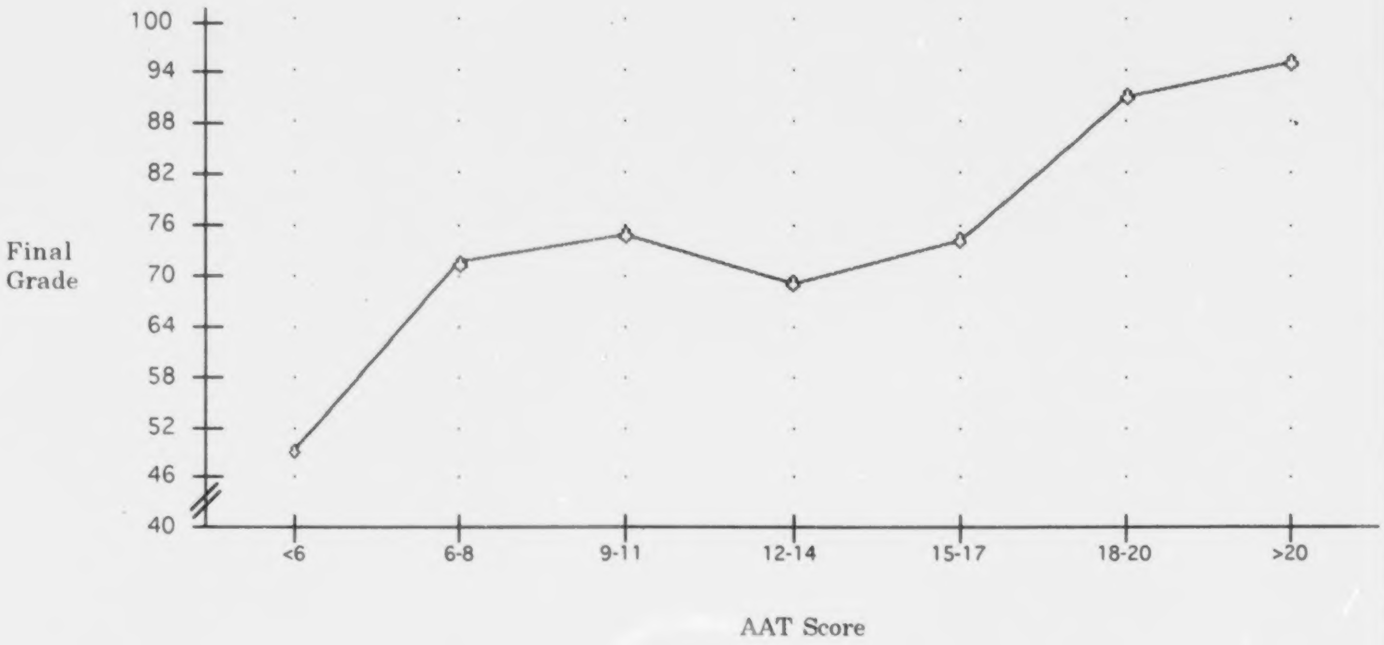

Figure 19. Mean Final Grades of Technical College #2 Students in Both Courses.

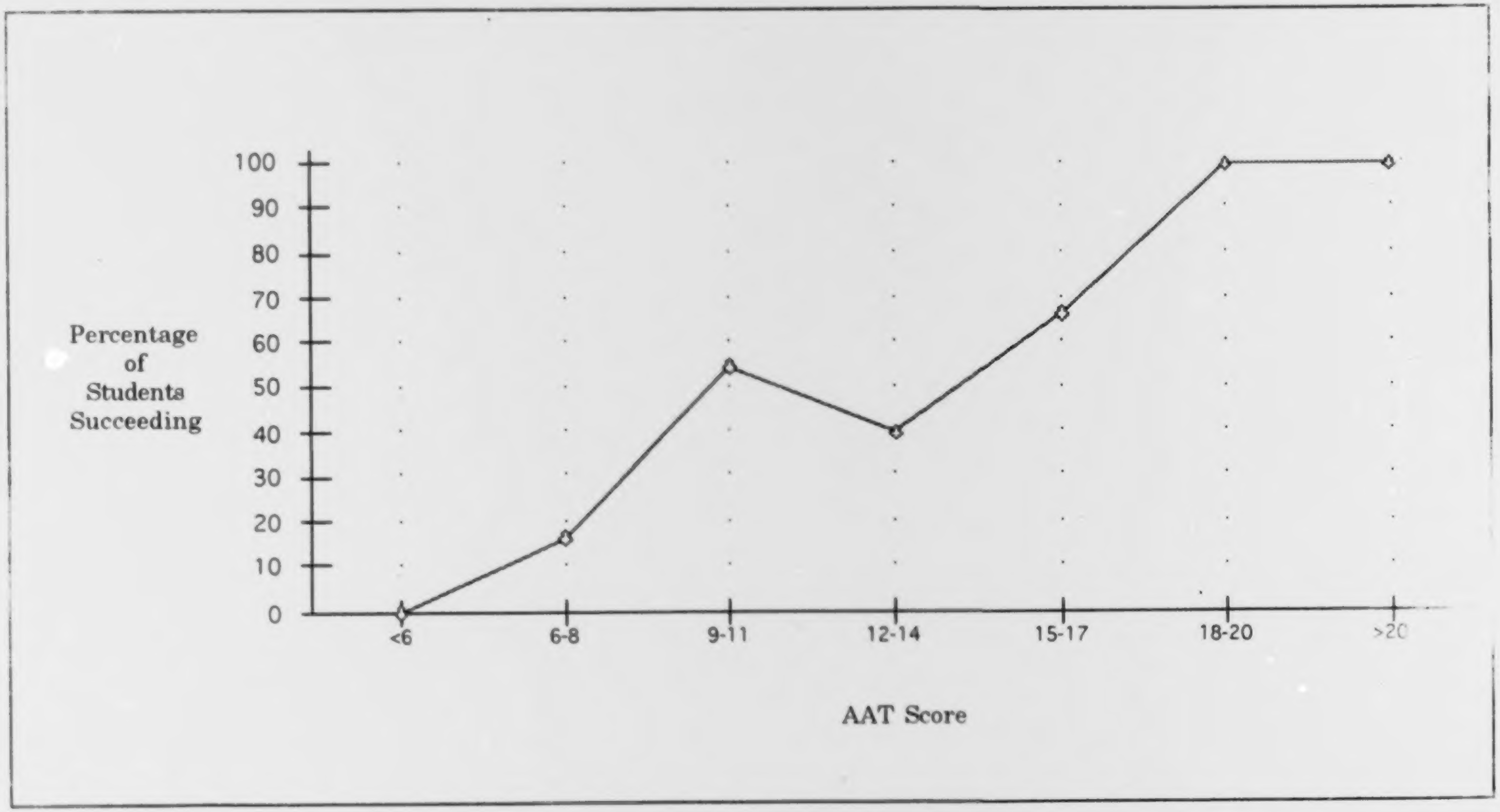

Figure 20. Percentage of All Students (Drop=Fail) Passing at Technical College #2, Grouped by AAT Score.

Technical College #3

Descriptive Statistics

61 students participated. There were 34 (56%) successful completions, 11 (18%) failures, and 16 (26%) drops. These percentages are fairly typical of the other institutions involved in the study (see Table 1, p. 65). Of those completing the course, the mean grade was 83.6, with a standard deviation of 10.4, while the median was 84. On the final exam, the mean was 75.0 with a standard deviation of 14.8, while the median was 74. In making comparisons to other institutions, be aware that this institution was the only one where the typical 90-80-70 grading scale was not in use (see Table 11). On the AAT, the mean grade was 11.6, with a standard deviation of 4.8, while the median grade was 10. These scores are fairly typical compared to the other institutions in the study (see Table 2, p. 65).

Table 11.

Comparison of Grading Scales used at Technical College #3 and All Other Institutions

Grade	Technical College #3	All Other Institutions
A	92 - 100	90 - 100
B	83 - 91	80 - 89
C	74 - 82	70 - 79
D	65 - 73	60 - 69
F	0 - 64	0 - 59

Correlational Analyses

The correlation of the AAT score to the final grade is r=.57; this is not statistically different from r=.35 (z=1.834, p<.05). Therefore the null hypothesis for Technical College #3 can not be rejected. Once again the relatively small sample size has failed to yield a significant result. With a relatively small sample size of only 50, the same effect would have yielded a significant result.

The correlation of the AAT score to the final exam grade was r=.58; this is not statistically different from r=.35 (z=1.925, P<.05). Therefore the null hypothesis for Technical College #3 can not be rejected. This time had there even been two more participants in the group, a significant result would have occurred (assuming the same effect size had been found).

Optimal Cut-Score Analysis

The success rate among those students completing the course is 76%, while the success rate among all students is 53%. The introduction of a cut-score does not help in the prediction of success among completers, but makes a dramatic difference in the prediction rate when drops are equated with failure (see Table 12). One could speculate here that there were many students with low AAT scores who realized they were not going to pass and who dropped the course. In all cases the optimal cut-score meets the minimum acceptable criteria of 67% correct predictions in the separation of likely successes and failures as set forth in this study. In all cases the test performed better than mere chance and was a particularly good performer when drops were included in the analysis.

Table 12.

Optimal AAT Cut-Scores at Technical College #3

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	6	73%	68%	.17
	7	73%	65%	.22
	8	73%	63%	.27
	9	73%	59%	.35
All Participants	13	71%	48%	.44
	14	71%	48%	.44

When looking at all scores, the optimal grey zone appears to be the 11-12 point range. If this is used as the grey zone, the success rate for students above this zone (AAT>12) is 100% among completers and 86% if counting drops as failures. The success rate for the lower group is not nearly as impressive (see Table 13). When drops are equated with failure, the failure rate among the lower group is nearly four times what it is among the higher group.

Table 13.

Success Rates at Technical College #3

AAT Score Range	Drop=Fail	Completers Only
<11	39%	57%
11-12	50%	67%
>12	86%	100%

AAT's Potential as a Placement Test at Technical College #3

The AAT seems to be an effective placement tool for this institution. There is a relatively strong correlation between performance on the AAT and both the final grade (see Figure 22) and the final exam grade (see Figure 23) that students receive in the course. There is a steady rise in final grades as AAT scores increase (see Figure 24). Note, however, the slight upturn in the *less than 6* (<6) category. This is again due to a few students scoring very well in the course despite low AAT scores. Including these scores in the analysis causes the average grades and passing rates of the lowest group to increase, creating a *phantom tail*.

The success rate of students when considering drops equivalent to failures demonstrates the power of the test as well (see Figure 25). Two important points need to be made regarding this figure. One can not help but notice that the success rate dips when the AAT score is over 20. This 50% success rate actually represents literally 1 out of 2 students. Also note the slight upturn in the less than 6 category. This again is most likely another phantom tail phenomenon, and is probably not a true representation of the performance of this ability group. Finally, the test seems to do an excellent job of separating those students who will likely pass from those who will likely fail (see Figure 26). In short, the test seems to meet all criteria set forth in this study. More testing would be required to fine tune the instrument, but the results from this sample are extremely encouraging.

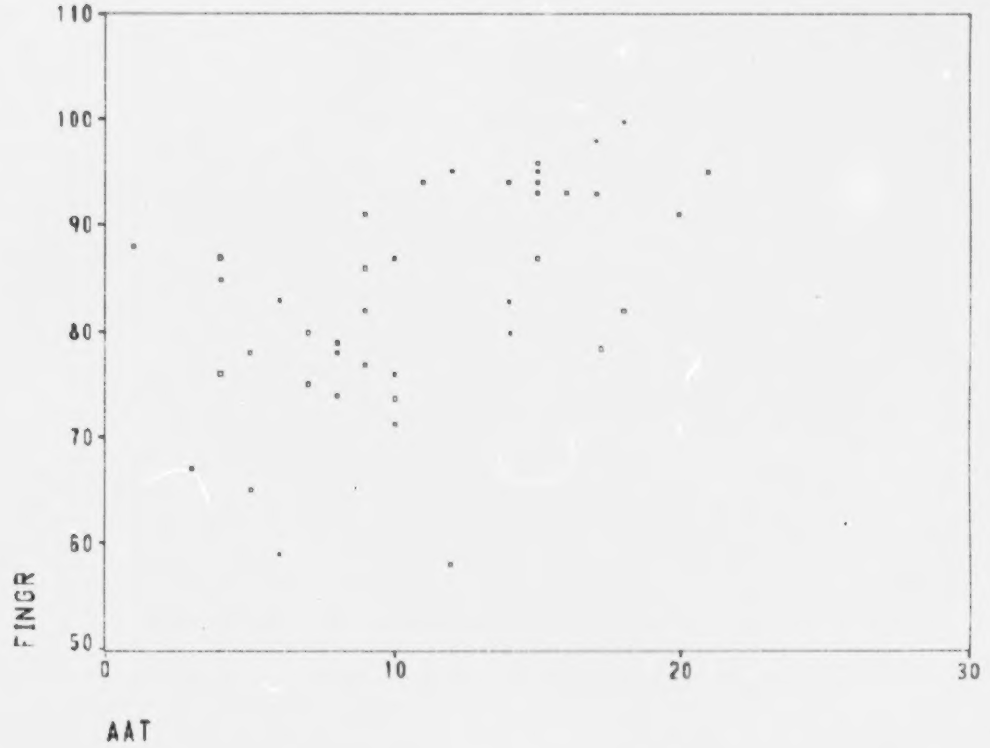

Figure 22. Scatter Graph of AAT Scores and Final Grades at Technical College #3.

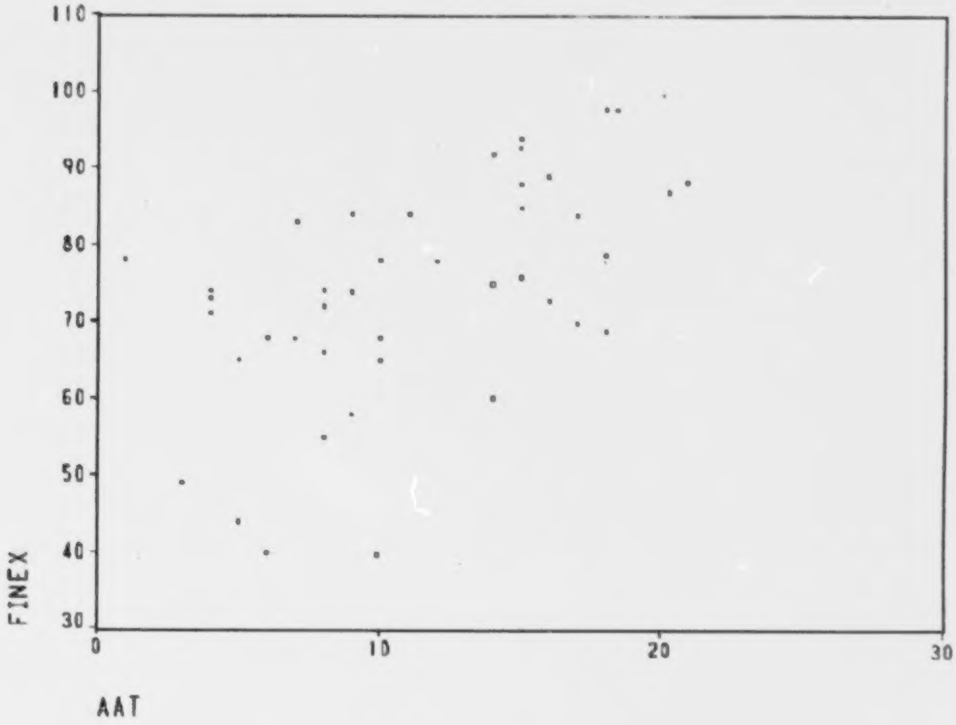

Figure 23. Scatter Graph of AAT Scores and Final Exam Grades at Technical College #3.

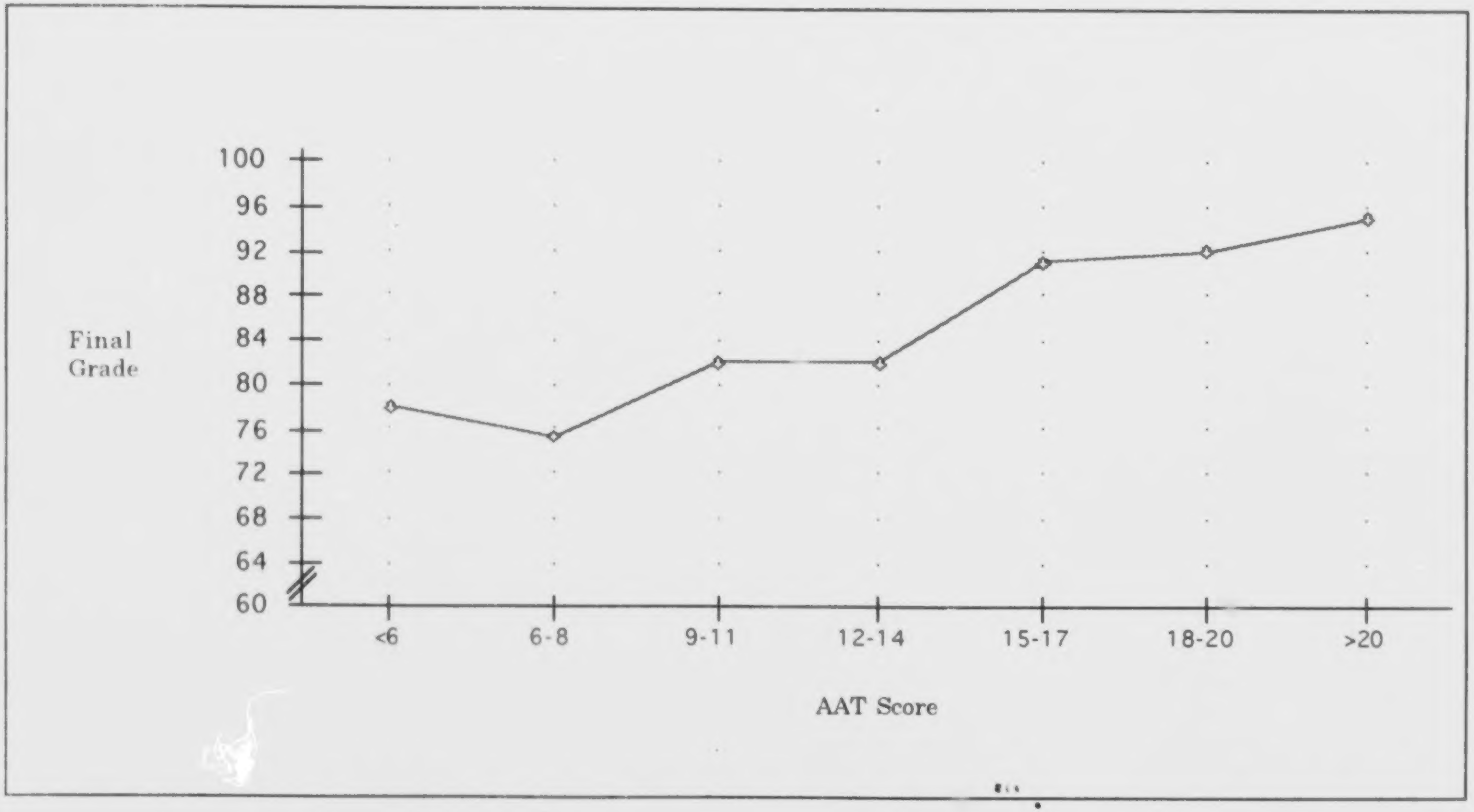

Figure 24. Mean Final Grades of Technical College #3 Students.

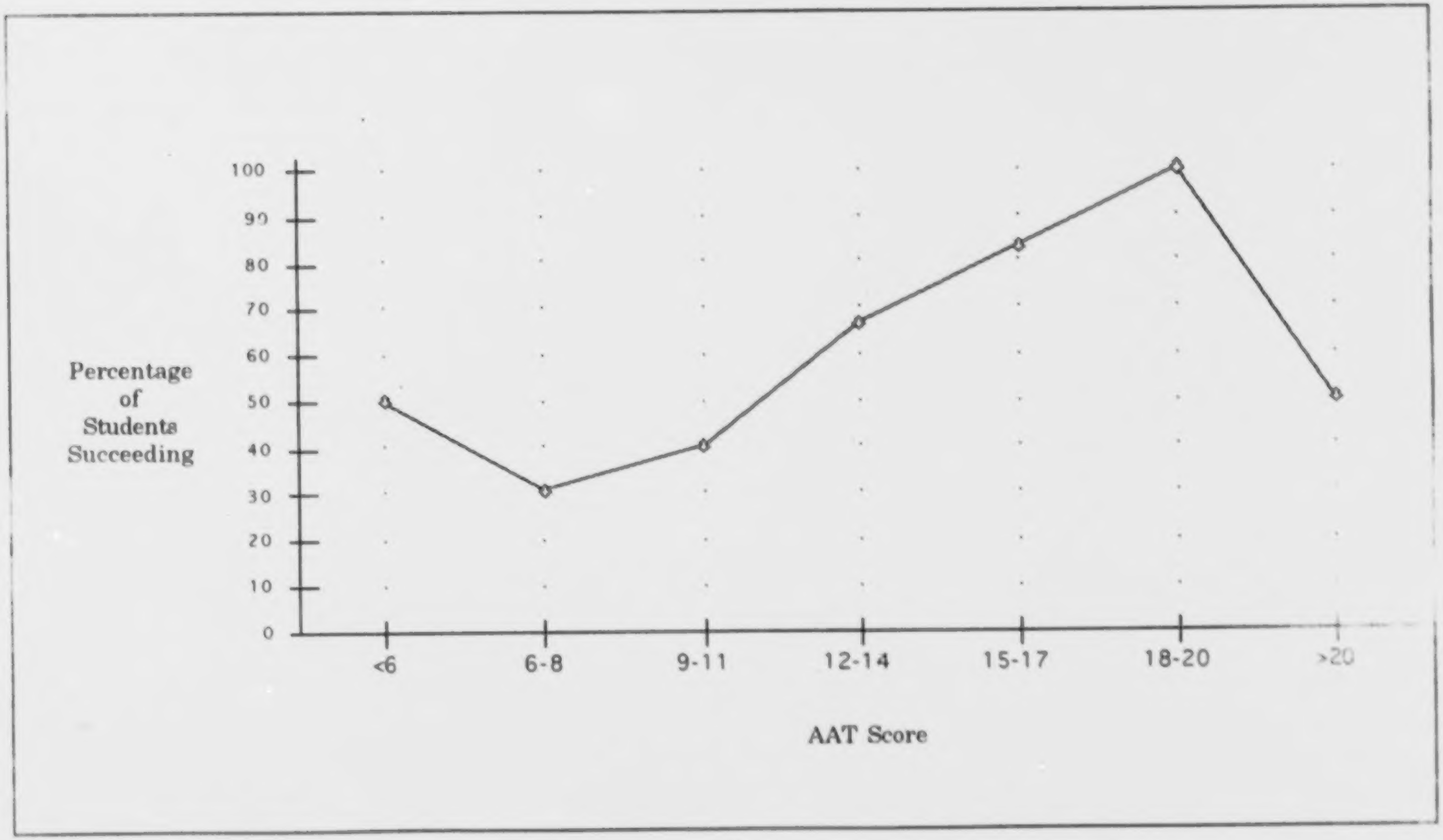

Figure 25. Percentage of All Students (Drop=Fail) Passing at Technical College #3, Grouped by AAT Score.

Technical College #4

Descriptive Statistics

77 students participated. There were 58 (75%) successful completions, 8 (10%) failures, and 11 (14%) drops. This success rate is higher than at most other institutions in the study (see Table 1, p. 64). Of those completing the course, the mean grade was 85.0 with a standard deviation of 12.3, while the median was 90. On the final exam, the mean was 81.0 with a standard deviation of 14.6, while the median was 85. On the AAT, the mean grade was 12.9 with a standard deviation of 4.8, while the median was 13. While the AAT averages are fairly representative of the other institutions in this study, the final grade and final exam averages are somewhat higher (see Table 2, p. 65).

Correlational Analyses

The correlation of the AAT score to the final grade is r=.39; this score is not statistically different from r=.35 (z=0.373, p>.05). The correlation of the AAT score to the final exam grade was r=.28; this is also not a statistically significant difference from r=.35 (z=-0.611, p>.05). Therefore neither null hypothesis $H_0 1$ nor $H_0 2$ is not rejected.

Optimal Cut-Score Analysis

The overall success rate at this institution is 88% for completers and 75% among all students. The introduction of optimal cut-scores improves these figures only slightly (see Table 14). However, in both cases the optimal cut-score meets the minimum acceptable criteria of 67% correct predictions in the separation of likely successes and failures as set forth in this study. Again the AAT performed better than random chance.

Table 14.

Optimal AAT Cut-Scores at Technical College #4

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	6	88%	86%	.17
All Participants	6	78%	73%	.19

One cannot help but to notice how low the optimal cut-scores are for this particular institution. This would presumably be due at least in part to distinctly higher pass rates at this institution (see Table 1, p. 64) and the higher final grades given (see Table 2, p. 65). Adjustments can be made, however, which seem to counteract the higher grades given, and make the test a more powerful instrument for this institution. If one raises the cutoff for a successful grade to an 85% (a solid B), the success rate drops to 62% for completers and 53% for all students. This brings this institution's success rates more into line with the success rates present at the other schools in this study. It yields a more reasonable cut-score of 13. Under these conditions, the test also performs more favorably compared to random chance (see Table 15). Whether or not raising the definition for success would be reasonable is strictly a decision left to the individual institution. It is merely done here to demonstrate the power of the AAT test when given a lower overall success rate among students.

Table 15.

Optimal AAT Cut-Scores at Technical College #4 (Success=85%)

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	13	65%	53%	.26
All Participants	13	64%	50%	.27

When looking at all scores and using 70% as the cutoff for a successful completion, the optimal grey zone appears to be in the 7-10 point range. If this is used as the grey zone, the success rate for students above this zone (scoring more than 10 on the AAT) is 96% among completers and 87% if counting drops equivalent to failures. Students scoring less than 7 points on the AAT (those students below the grey zone) and completing the course have a 67% success rate. If drops are counted as failures, the success rate in this group drops to 50% (see Table 16).

Table 16.

Success Rates at Technical College #4.

AAT Score Range	Drop=Fail	Completers Only
<7	50%	67%
7-10	57%	73%
>10	87%	96%

Using 85% as a cutoff for success, results in somewhat different values (see Table 17). The optimal grey zone would be in the 9-12 range, which brings it again more into line with the other institutions in the study. In the area above the grey zone, the success rates are 74% and 64% when considering only completers and all students (drop=fail), respectively. For the students scoring below the grey zone, the success rates are 46% and 35% when considering only completers and all students (drop=fail), respectively. Again, this information is given only for comparison purposes. Any actual decision as to cut-scores must of course be left to individual institutions.

Table 17.

Success Rates (Success=>85%) at Technical College #4

AAT Score Range	Drop=Fail	Completers Only
<9	35%	46%
9-12	39%	47%
>12	64%	74%

AAT's Potential as a Placement Test at Technical College #4

The AAT seems to be a somewhat effective placement tool for this institution. There is a moderate correlation between performance on the AAT and the final grade students receive in the course (see Figure 27), and a somewhat weaker correlation between the AAT and the final exam (see Figure 28). There is a distinct and steady rise in final grades as AAT scores increase (see Figure 29). The success rate of students when considering drops equivalent to failures demonstrates the power of the test as well (see Figure 30). Two important points need to be made regarding this graph. One can not help but notice that the success rate dips when the AAT score rises above the 12-14 point range. For some reason, the group with AAT scores higher than 12-14 had a higher drop rate than would be expected comparing it to other institutions. Also, note the relatively small numbers this graph represents. If one were to delete a single drop from each of the final three ranges of AAT scores, the graph would be a constantly increasing function (have a positive slope over the entire range of scores), as would be expected. For example, consider the 50% success rate in the >20 category. This 50% success rate actually represents 1 out of 2 students (1 student passed and 1 student dropped). If one were to remove only this 1 student who dropped from the sample, the success rate would be 100%. If one removes the drops and examines the success rates of only those students completing the class, the dip at the end is removed (see Figure 31).

The test also seems to be adequate in separating those students who will likely pass from those who will likely fail (see Figure 32). The test seems to meet or exceed virtually all criteria as set forth in this study. The unusually high success rate and higher grades given at this institution seem to make it less compatible with the test and parameters as they now stand. However, given the moderate correlation and superior results obtained if one brings this institution's scores into line with other institutions in this study, there is reason to believe that with some modifications, the instrument would be acceptable for use at this institution. More testing would be required to fine tune it, but the results from this sample are encouraging.

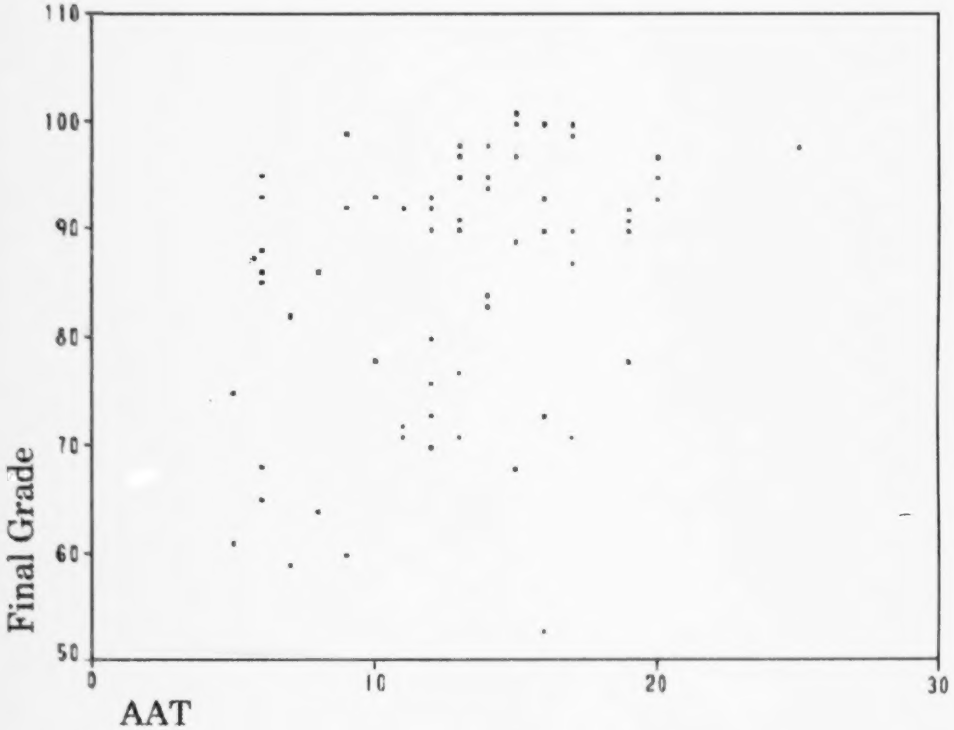

Figure 27. Scatter Graph of AAT Scores and Final Grades at Technical College #4.

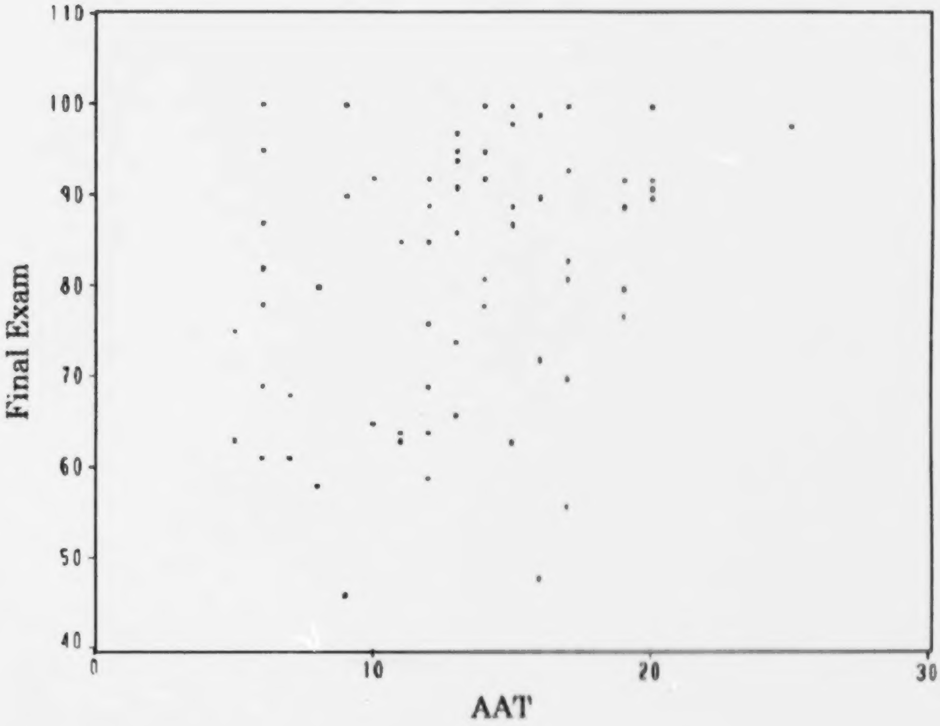

Figure 28. Scatter Graph of AAT Scores and Final Exam Grades at Technical College #4.

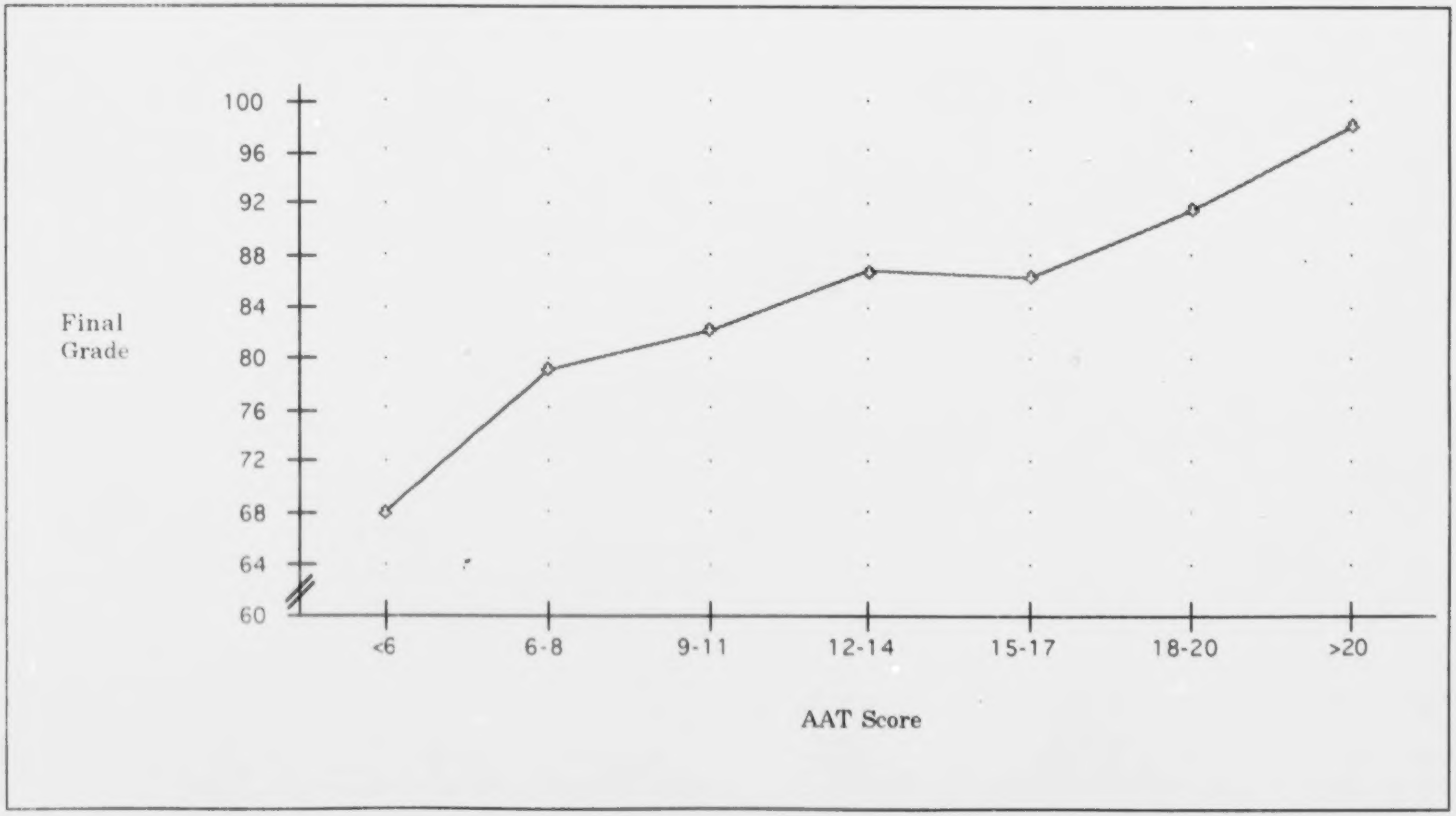

Figure 29. Mean Final Grades of Technical College #4 Students.

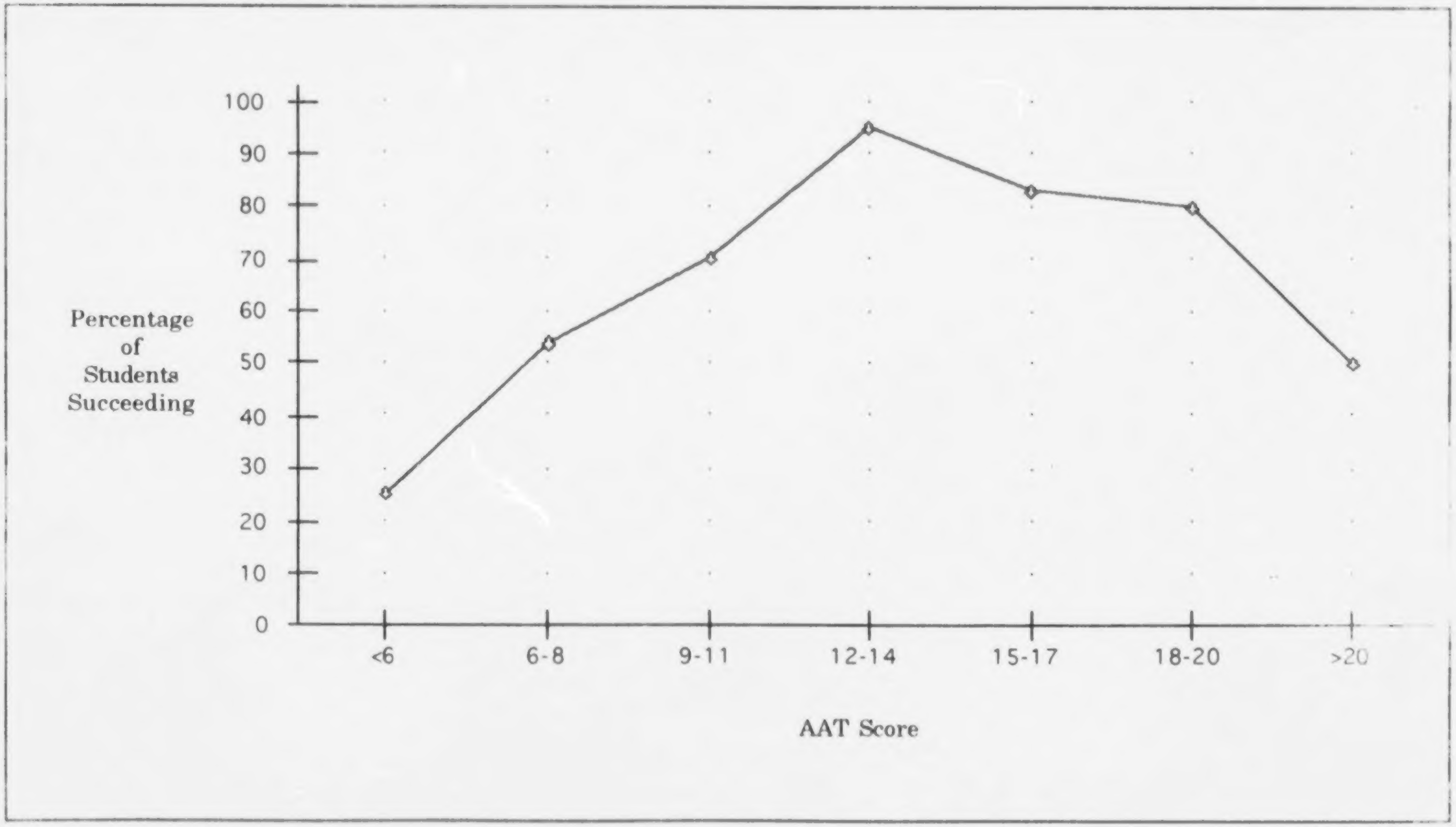

Figure 30. Percentage of All Students (Drop=Fail) Passing at Technical College #4, Grouped by AAT Score.

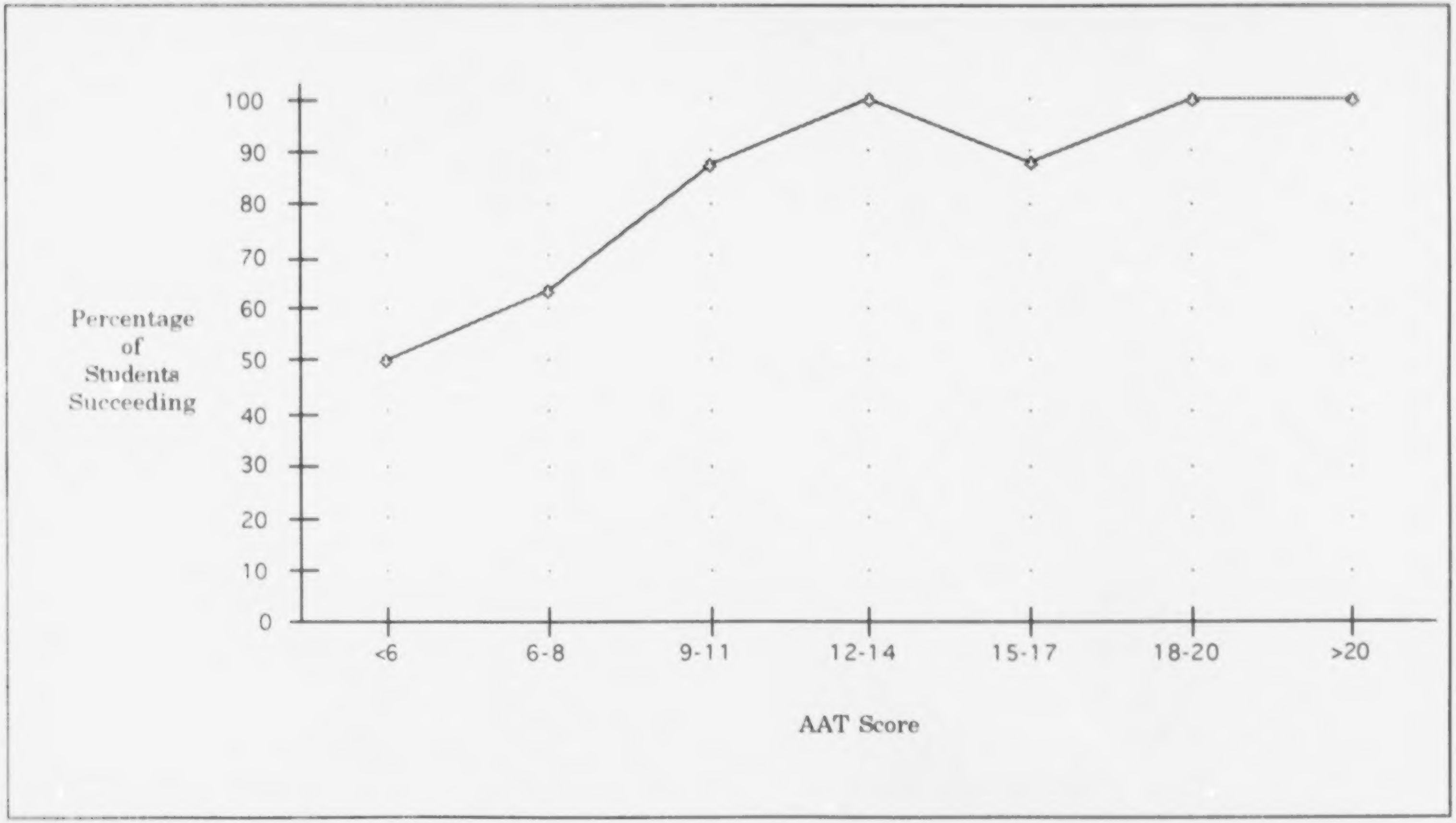

Figure 31. Percentage of Completers Passing at Technical College #4, Grouped by AAT Score.

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Technical College #5

Analysis of Algebra and Trigonometry I (Math119)

Descriptive statistics.

25 students participated. There were 15 (60%) successful completions, 1 (4%) failure, and 9 (36%) drops. Of those completing the course, the mean grade was 86.8, with a standard deviation of 8.5, while the median was 86.5. On the final exam, the mean was 84.2 with a standard deviation of 16.1, while the median was 87. On the AAT, the mean grade was 18.8 with a standard deviation of 4.4, while the median was 20. This group of students had high grades, a low failure rate, and especially high AAT scores when compared to the other institutions in the study (see Table 1, p. 64 and Table 2, p. 65).

Correlational analyses.

The correlation of the AAT score to the final grade was r=.74; this is statistically significant (z=2.109, p<.05). Therefore the null hypothesis $H_0$1 for Algebra and Trigonometry I (Math119) at Technical College #5 is rejected.

The correlation of the AAT score to the final exam grade was r=.78, this is statistically significant (z=2.452, p<.05). Therefore the null hypothesis $H_0$1 for Algebra and Trigonometry I (Math119) at Technical College #5 is rejected.

Optimal cut-score analysis.

The overall passing rate in this course at this institution is 96% among completers and 60% overall. Introducing a cut-score improves these percentages. The optimal AAT cut-score can be anything from 10 to 15 when drops are not considered, resulting in correct predictions 100% of the time (see Table 18). This is a bit misleading, however, in that only one student received a failing score in this course. The optimal cut-score when one considers drops equivalent to failure is 15, resulting in correct predictions 80% of the time. The test performs well in that in each case it proves itself to be a distinctly better performer than chance alone. However, the failure rate among completers is particularly low, and the only student to fail had the lowest score on the AAT. This yields an unrealistic prediction rate. Both scores, however, meet the minimum criteria of 67% as forth in this study.

Table 18.

Optimal AAT Cut Scores for Algebra and Trigonometry I (Math119) at Technical College #5

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	10-15	100%	88%	1.0
All Participants	15	80%	56%	.55

One can again choose a different definition for success in order to gain a higher failure rate. Raising the definition of a successful course completion to a final grade of 85% makes sense since only one student scored below the traditional cutoff of a final grade of 70% used in this study. If one chooses to use 85% as the cutoff for a successful completion, the result is a 44% success rate among all students and 69% among completers. The test substantially improves on these numbers. The optimal cut-score under these parameters would be 17, resulting in correct predictions 72% of the time among all students and 88% of the time among completers. Under these conditions the test performs quite well when compared to chance (see Table 19). No matter what parameters one chooses, however, the optimal cut-score meets the minimum criteria of 67% for separation of likely successes and failures in all cases.

Table 19.

Optimal AAT Cut Scores for Algebra and Trigonometry I (Math119) at Technical College #5 (Success=85%)

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	17	88%	62%	.68
All Participants	17	72%	47%	.47

It is interesting that there is not a true grey zone for this particular course (when we use the standard of 70% in defining successful completions). Students scoring below 15 on the AAT all either fail or drop the class, resulting in a 0% success rate for both all students and completers. There are only five students scoring below 15, however, so one must take into account the small size of this sample. Of those scoring 15 or higher on the AAT, 100% who finish the course pass successfully; the success rate is 75% when counting drops as equivalent to failure.

If we again use 85% as the cutoff for a successful completion, there is still no true grey zone. Everyone scoring under 17 (the optimal cut-score) on the AAT was either unsuccessful or dropped the class (i.e. a 0% success rate for both completers and all students). The success rates among those scoring 17 or higher was 85% among completers and 61% among all students. In deciding which cut-score should be used, one must first decide on the desired outcome for students. These decisions, as always, are up to the local institutions, and the different parameters are presented here only as a way of demonstrating the power of the test.

AAT's potential as a placement test for Algebra and Trigonometry I (Math 119) at Technical College #5.

The AAT seems to be a somewhat effective placement tool for this course at this institution. Although the AAT scores are compacted into a narrow range of values, there is a strong correlation between performance on the AAT and both the final grade (see Figure 33) and the final exam grade (see Figure 34) that students receive in the course. Final grades definitely rise corresponding to a rise to AAT scores (see Figure 35), but this rise is limited due to the compact distribution of AAT scores. The substantially higher AAT scores among Technical College #5 students would seem to indicate that students entering this class have a superior background in arithmetic compared with those students in other classes at other institutions.

The success rate of students, when one considers drops equivalent to failure, demonstrates the power of the test (see Figure 36). Note the distinct peak in the 15-17 point range on the AAT. There were only 3 students scoring in this point range and they all passed the course successfully. Finally, the test seems to be adequate in separating those students who will likely pass from those who will likely fail (see Figure 37). The small number of students in the sample and the limited range of scores on the AAT make interpretation more difficult, but there is most definitely a relationship between the AAT and success in this course. More testing would be required to fine tune the instrument, but the results from this sample are very encouraging.

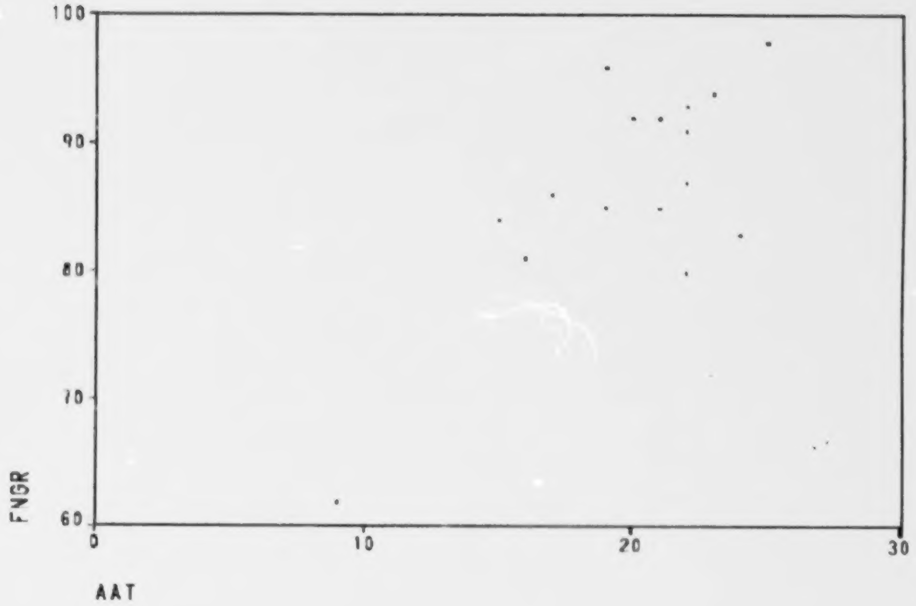

Figure 33. Scatter Graph of AAT Scores and Final Grades from Algebra and Trigonometry I (Math119) at Technical College #5.

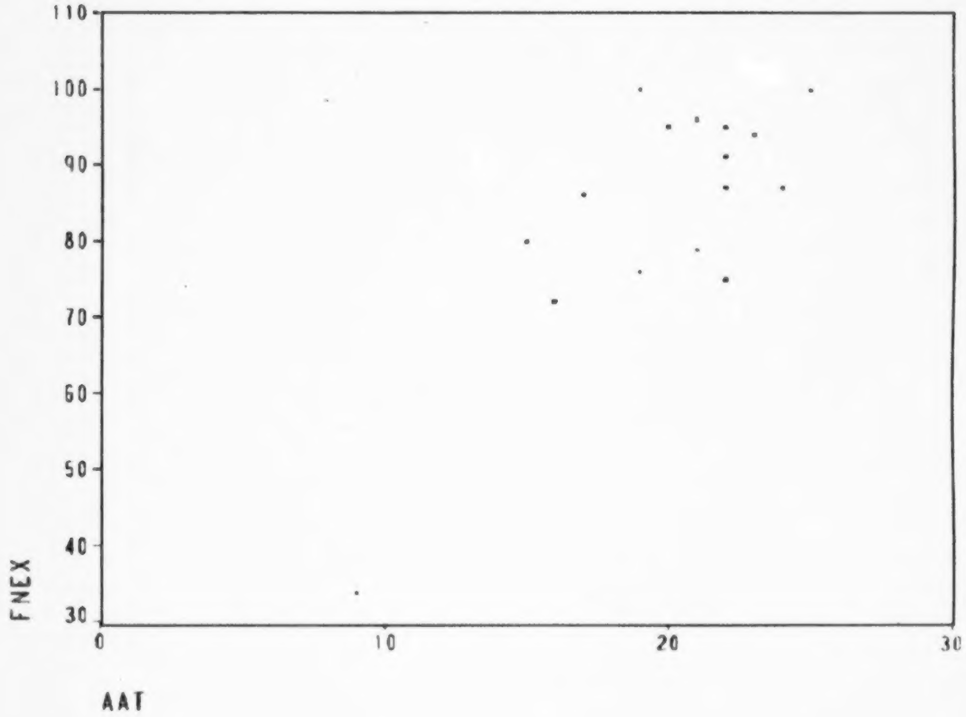

Figure 34. Scatter Graph of AAT Scores and Final Exam Grades from Algebra and Trigonometry I (Math119) at Technical College #5.

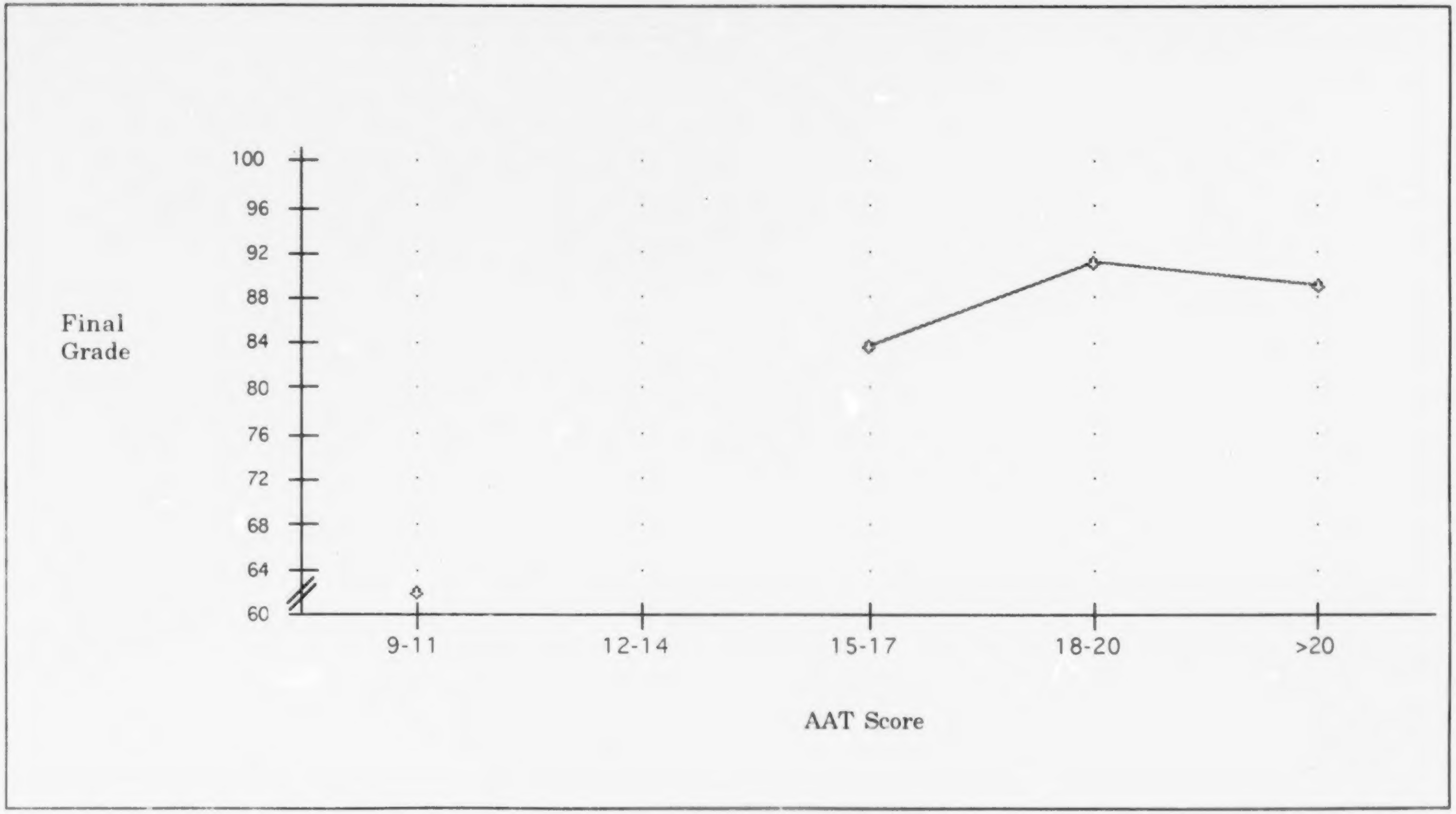

Figure 35. Mean Final Grades of Technical College #5 Algebra and Trigonometry I (Math119) Students.

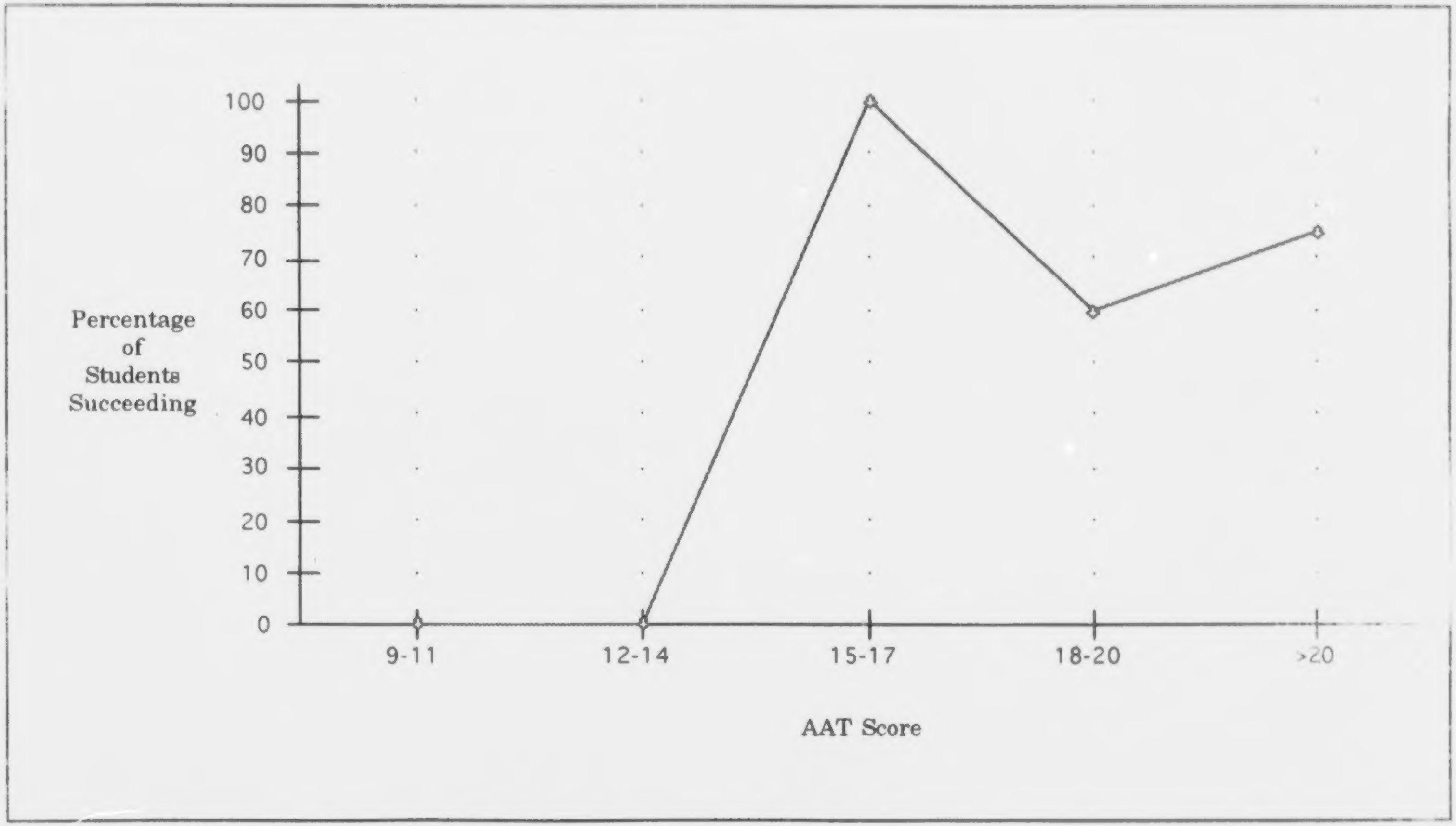

Figure 36. Percentage of All Students Passing (Drop=Fail) Algebra and Trigonometry I (Math119) at Technical College #5, Grouped by AAT Score.

Analysis of Technical Math I (Math117)

Descriptive statistics.

31 students participated. There were 18 (58%) successful completions, 3 (10%) failures, and 10 (32%) drops. Of those completing the course, the mean grade was 79.6, with a standard deviation of 11.4, while the median was 81. On the final exam, the mean was 72.9 with a standard deviation of 16.2, while the median was 74. On the AAT, the mean grade was 18.2 with a standard deviation of 3.3, while the median was 18. The failure rate for this course was somewhat lower (see Table 1, p. 64) and the AAT scores for these students distinctly higher (see Table 2, p. 65) when compared to the other students and institutions in the study.

Correlational analyses.

The correlation of the AAT score to the final grade was r=.19. This result is not statistically different from r=.35 (z=-0.734, p>.05). The correlation of the AAT score to the final exam was r=.13. This score is also not statistically different from r=.35 (z=-.99, p>.05). Therefore the null hypotheses as set forth in $H_0 1$ and $H_0 2$ of this study can not be rejected.

Optimal cut-score analysis.

There is no optimal cut-score that will improve upon the success rate of 86% for completers in this course. The students with the lowest AAT scores performed quite well in the class. Any cut-score up to and including 12 will equal this prediction rate however, as no one in this course received an AAT score under 12. The test technically still meets the 67% criterion as set forth in this study. This result, however, is of little substantive value. The fact that the optimal cut score is lower than any student scored on the test, leaves further examination pointless.

The optimal cut-score when counting drops as failures is 14 or 15, resulting in correct predictions 61% of the time. This is slightly better than the overall success rate of 58% for students in this course and represents only a small improvement over random assignment (see Table 20). This is less than the standard of 67% set forth in this study.

Table 20.

Optimal AAT Cut Scores for All Students (Drop=Fail) in Technical Math I (Math117) at Technical College #5

Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
14	61%	57%	.10
15	61%	55%	.12

The lack of success in this course is due in part to the relatively low number of failures for this group. Only three students received final grades which were below the 70% cutoff used to separate the successes from the failures. If one chooses a final grade of 80% as the cutoff only 42% of all students are successful, and only 62% of the completers. Using 22 as the optimal cut-score on the AAT results in a prediction success rate of 68% for all students. Using anything in the 18-20 range results in correct predictions 62% of the time among completers. These scores also compare favorably when considering the amount of randomness of the test (see Table 21). Unfortunately the optimal cut score of 22, used when all students are included in the analysis, is high even for this institution. Only 17% of students reach this benchmark. Although the sample size may be a contributing factor, the AAT seems to be of only minimal value when placing students based on a cut-score for this course in this institution.

Table 21.

Optimal Cut Scores for Technical Math I (Math117) at Technical College #5 (Success=80%)

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	18	62%	52%	.19
	19	62%	51%	.23
	20	62%	48%	.26
All Participants	22	68%	55%	.28

Using the standard of 70% as the definition of success, the best grey zone for this course seems to be the 17-20 range. As there were only three failures in the course, discussion of the success rates among completers is left out. Students scoring below 17 on the AAT succeed 50% of the time.

Students scoring in the 17-20 range do slightly better, succeeding 55% of the time. Those students scoring above 20 points succeed 70% of the time.

If one again regards 80% as the cutoff for a successful completion, there are more failures and the optimal grey zone on the AAT rises and condenses to 20-21. The success rate for those students below the grey zone (AAT<20) is only 50% among completers and 33% among all students. The success rates for those students above a 21 is 100% for completers and 80% for all students (see Table 22). Again this higher standard was used only to demonstrate the power of the test. Any such actual change in the parameters would, by necessity, have to come from the local institution.

Table 22.

Success Rates (Success=>80%) at Technical College #5 (Math117)

AAT Score Range	Drop=Fail	Completers Only
<20	33%	50%
20-21	57%	60%
>21	80%	100%

AAT's potential as a placement test in Technical Math I (Math 117) at Technical College #5.

The results of the analysis for this course are somewhat mixed, but regardless of what position one takes, there is an obvious need for some additional fine tuning and more research before one could consider using the AAT as a placement instrument for this course. Although the range of AAT scores is again compacted into a narrow range of values, there is a definite relationship between performance on the AAT and both the final grades (see Figure 38) and the final exam grades (see Figure 39) that students receive in the course. In examining the scatter plots, it becomes obvious that a handful of scores drastically altered the correlation coefficients used to judge the strength of this relationship. The substantially higher AAT scores among this group of students would seem to indicate that students entering this class have a superior background in arithmetic compared those students at other institutions.

In general as the AAT scores increase there is a corresponding rise in final grades (see Figure 40). In examining Figure 40, one must realize that the mean score in the 12-14 category represents the scores of only 2 students. The success rate of students when one counts drops as equivalent to failures demonstrates that the test may have some value as well (see Figure 41). The test also seems to be of some value in separating those students who will likely pass from those who will likely fail (see Figure 42). The overall results of the use of the AAT for Math117 are somewhat encouraging, but more testing and fine tuning would definitely be desirable before actually putting this test into use as a placement instrument for this class. Altering the definitions for success make a dramatic difference in test performance. It is quite possible, as well, that by isolating the problems that correlated most highly with success and building on those, a more suitable test could be developed. If done properly, the degree of difficulty could be raised, spreading the students' scores over a wider range and perhaps resulting in a test with a stronger correlation which would have better predictive value as well.

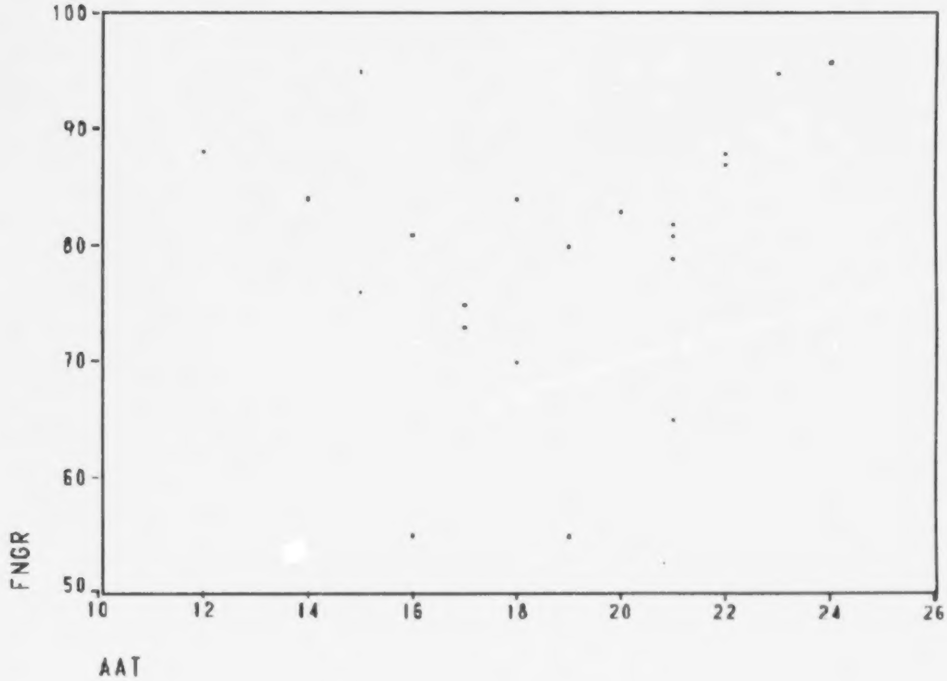

Figure 38. Scatter Graph of AAT Scores and Final Grades from Technical Math I (Math117) at Technical College #5.

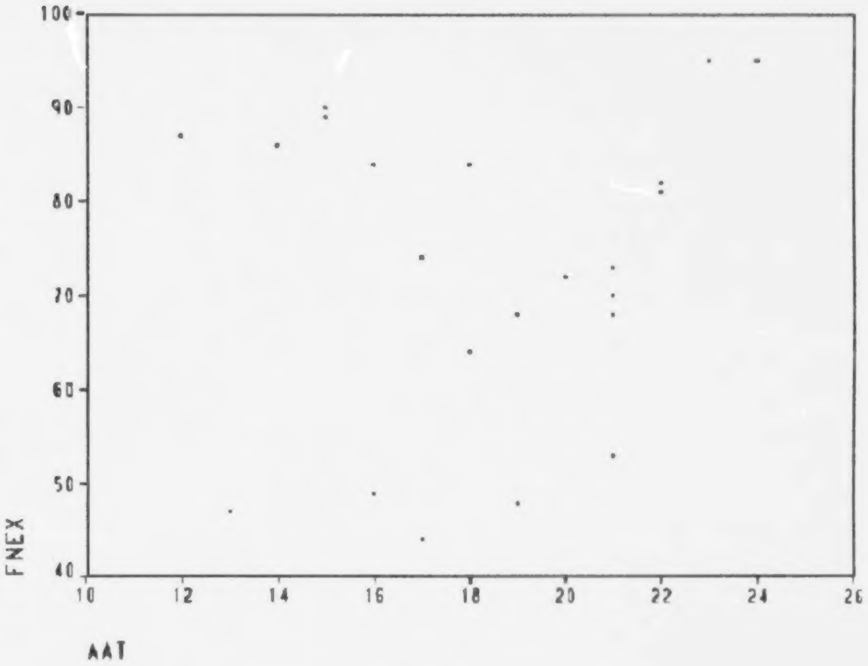

Figure 39. Scatter Graph of AAT Scores and Final Exam Grades from Technical Math I (Math117) at Technical College #5.

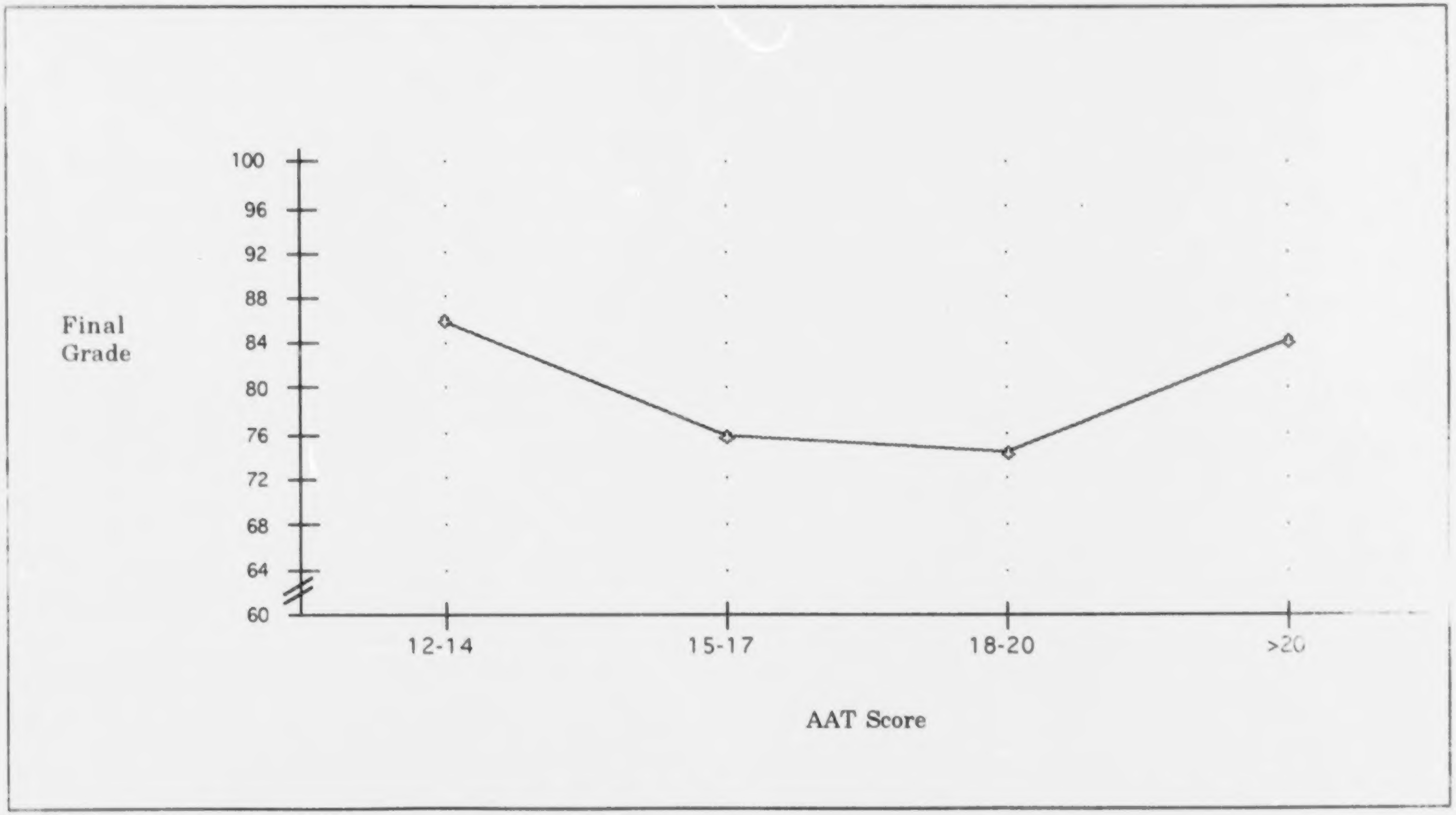

Figure 40. Mean Final Grades of Technical Math I (Math117) Students at Technical College #5.

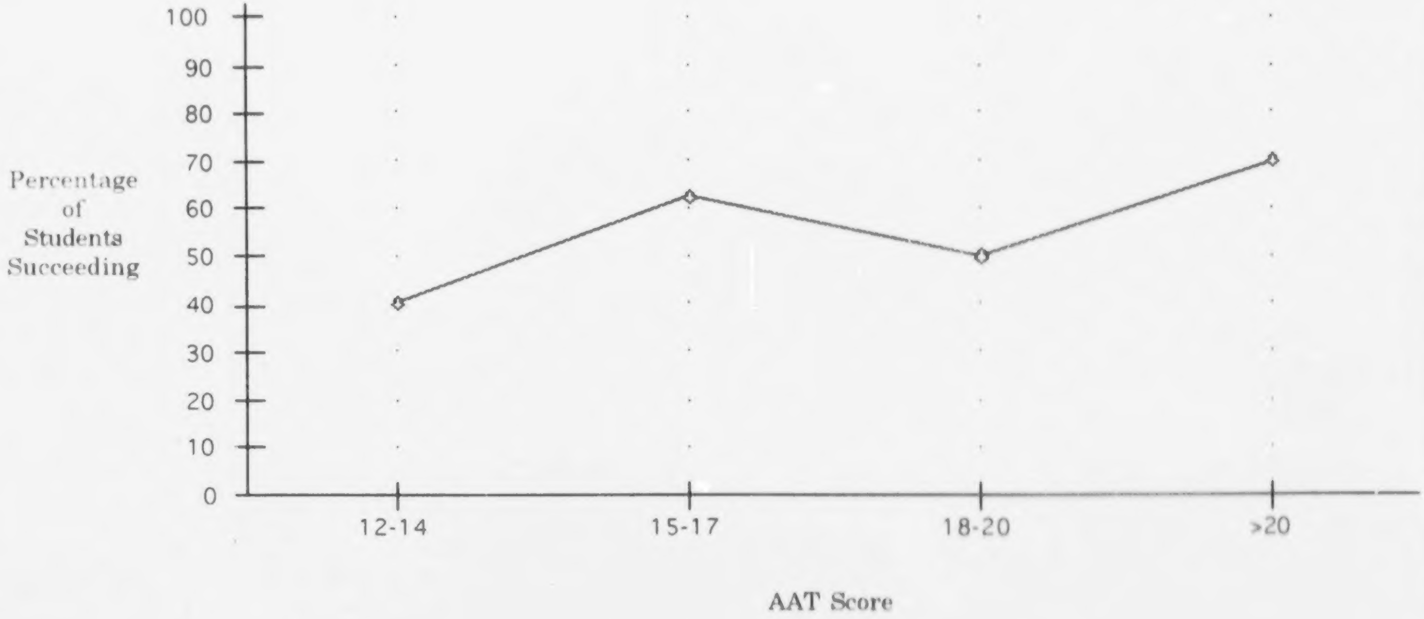

Figure 41. Percentage of All Students (Drop=Fail) Passing Technical Math I (Math117) at Technical College #5, Grouped by AAT Score.

Analysis Across Both Math117 and Math119

Descriptive statistics.

56 students participated. There were 33 (59%) successful completions, 4 (7%) failures, and 19 (34%) drops. This institution had a failure rate that was relatively low compared to other institutions in the study (see Table 1, p. 64). Of those completing the course, the mean grade was 82.7, with a standard deviation of 10.7, while the median was 84. On the final exam, the mean was 77.6 with a standard deviation of 16.9, while the median was 81.5. On the AAT, the mean grade was 18.5 with a standard deviation of 3.9, while the median was 19. The average AAT at this institution was far above the average of other institutions involved in the study (see Table 2, p. 65).

Correlational analyses.

The correlation of the AAT score to the final grade was $r=.43$, which is not statistically different from $r=.35$ ($z=0.554$, $p>.05$). Therefore null hypothesis $H_0 1$ can not be rejected. Once again, the sample size was not sufficient to produce a significant result. The correlation of the AAT score to the final exam grade was $r=.46$, which is not statistically different from $r=.35$ ($z=0.770$, $p>.05$). Therefore null hypothesis $H_0 2$ can not be rejected. Again, the small sample size was a factor in the lack of a significant result.

Optimal cut-score analysis.

The overall pass rate among all students at this institution is 59% overall and 89% among completers. The introduction of optimal cut-scores improves these rates (see Table 23). The optimal cut-score meets the minimum acceptable criteria of 67% correct predictions in the separation of likely successes and failures as set forth in this study. The analysis of completers, however, is somewhat misleading. With such a high percentage of completers passing it would be virtually impossible to arrive at a percentage rate below 67%. The prediction success rate among all students shows solid improvement, both when compared to the existing passing rate and the percentage of predictions based solely on chance.

Table 23.

Optimal AAT Cut-Scores at Technical College #5

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	10-12	92%	87%	.38
All Participants	15	70%	56%	.31

With so few failures, it is worth considering what happens if one raises the definition of success to a score of 80%. Only 50% of all students and only 76% of completers meet this criterion. The introduction of cut-scores improves on both of these percentages (see Table 24), but again the test is most effective when applied to all students. As has been previously stated, the decision to redefine success must be determined by the home institution. The data is merely presented here for the purpose of demonstrating the potential power of the test if this institution had a higher failure rate.

Table 24.

Optimal AAT Cut-Scores at Technical College #5 (Success=80%).

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	10-12	78%	74%	.14
All Participants	20	66%	50%	.32

Using 70% as the definition of a successful completion, the optimal grey zone appears to be in the 16-19 point range. There is a distinct difference between passing rates for those above the grey zone compared with those below the grey zone (see Table 25). Completers below the grey zone are three times more likely to fail than those above the grey zone, and the failure rate for all students (drop=fail) is twice as high for those below the grey zone compared to those above.

If one considers 80% as the cutoff for success, the analysis changes (see Table 26). The optimum grey zone becomes smaller and higher- 19-21 points. Among completers, the failure rate is more than five times as great for those below the grey zone compared to those above the grey zone. Among all students, the failure rate in the group below the grey zone is more than three times that of the group above the grey zone. Although these results are more favorable, each institution must decide where the cutoff for a successful completion should be set. The data are presented here only to provide an example of the test's power when higher failure rates exist.

Table 25.

Success Rates at Technical College #5.

AAT Score Range	Drop=Fail	Completers Only
<16	31%	63%
16-19	59%	83%
>19	68%	89%

Table 26.

Success Rates (Success=>80%) at Technical College #5.

AAT Score Range	Drop=Fail	Completers Only
<19	31%	50%
19-21	50%	75%
>21	79%	91%

AAT's potential as a placement test at Technical College #5.

The AAT seems to be a relatively effective placement tool for this institution as a whole. Combining both courses into a single analysis gives a larger sample and more reliable results. There is a definite relationship between performance on the AAT and both the final grades (see Figure 43) and the final exam grades (see Figure 44) that students receive in the course. As AAT score increase there is a corresponding increase in course grades (see Figure 45). Note that the average of 86 in the 12-14 group represents only two cases. Also consider that this is a very narrow range over which to judge the effect.

The success rate of students when counting drops as equivalent to failures demonstrates the power of the test as well (see Figure 46). One must also take into consideration, however, that the 0% success rate among students in the 9-11 range represents only three students, all of whom dropped the course. The test also seems to be adequate in separating those students who will likely pass from those who will likely fail (see Figure 47).

While the results from this sample are fairly encouraging, one again must note that this sample of students is distinctly different from those taken from the rest of the institutions in the study. The narrow range of AAT scores certainly had a negative effect on the strength of the test, although there is still a relatively strong correlation. With such a narrow range of scores, making distinctions with cut-scores is more difficult and less effective. It is worth noting that changing certain parameters makes the test more efficient. Further research could perhaps be used to alter the AAT for this institution and enhance the results found in this study.

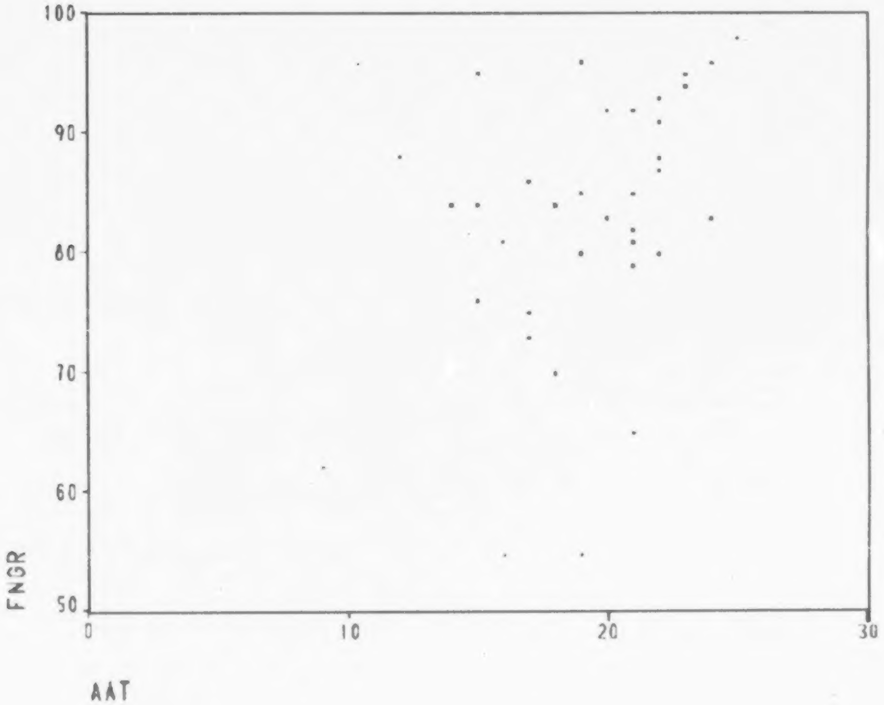

Figure 43. Scatter Graph of All AAT Scores and Final Grades at Technical College #5 (Both Courses).

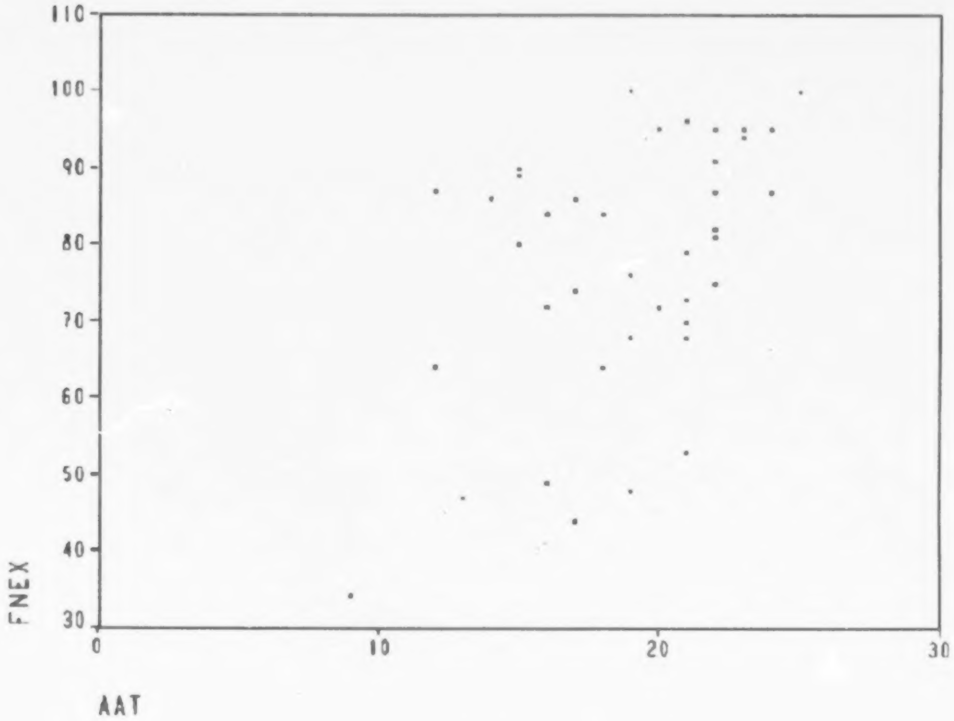

Figure 44. Scatter Graph of All AAT Scores and Final Exam Grades at Technical College #5 (Both Courses).

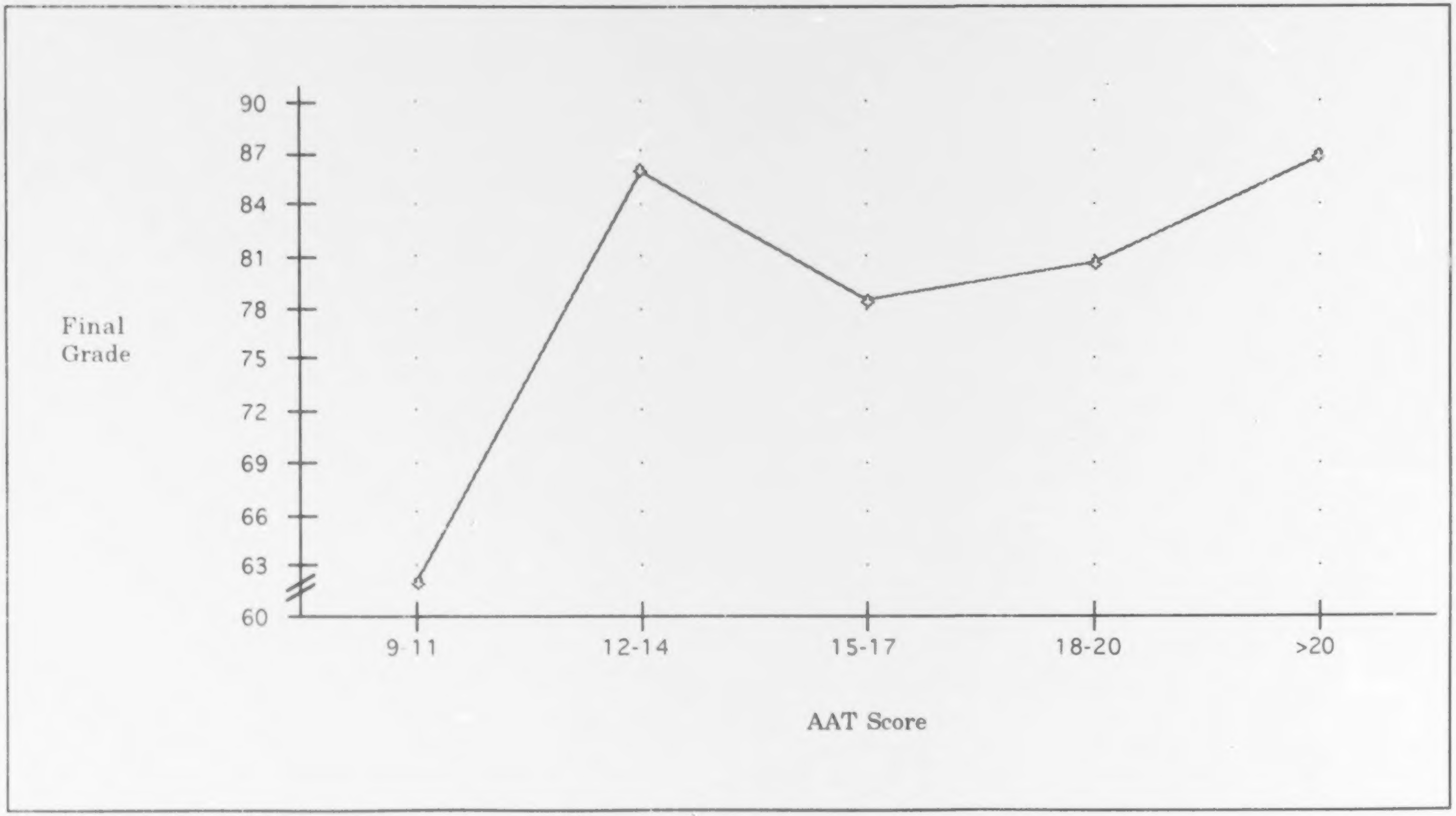

Figure 45. Mean Final Grades of All Technical College #5 Students.

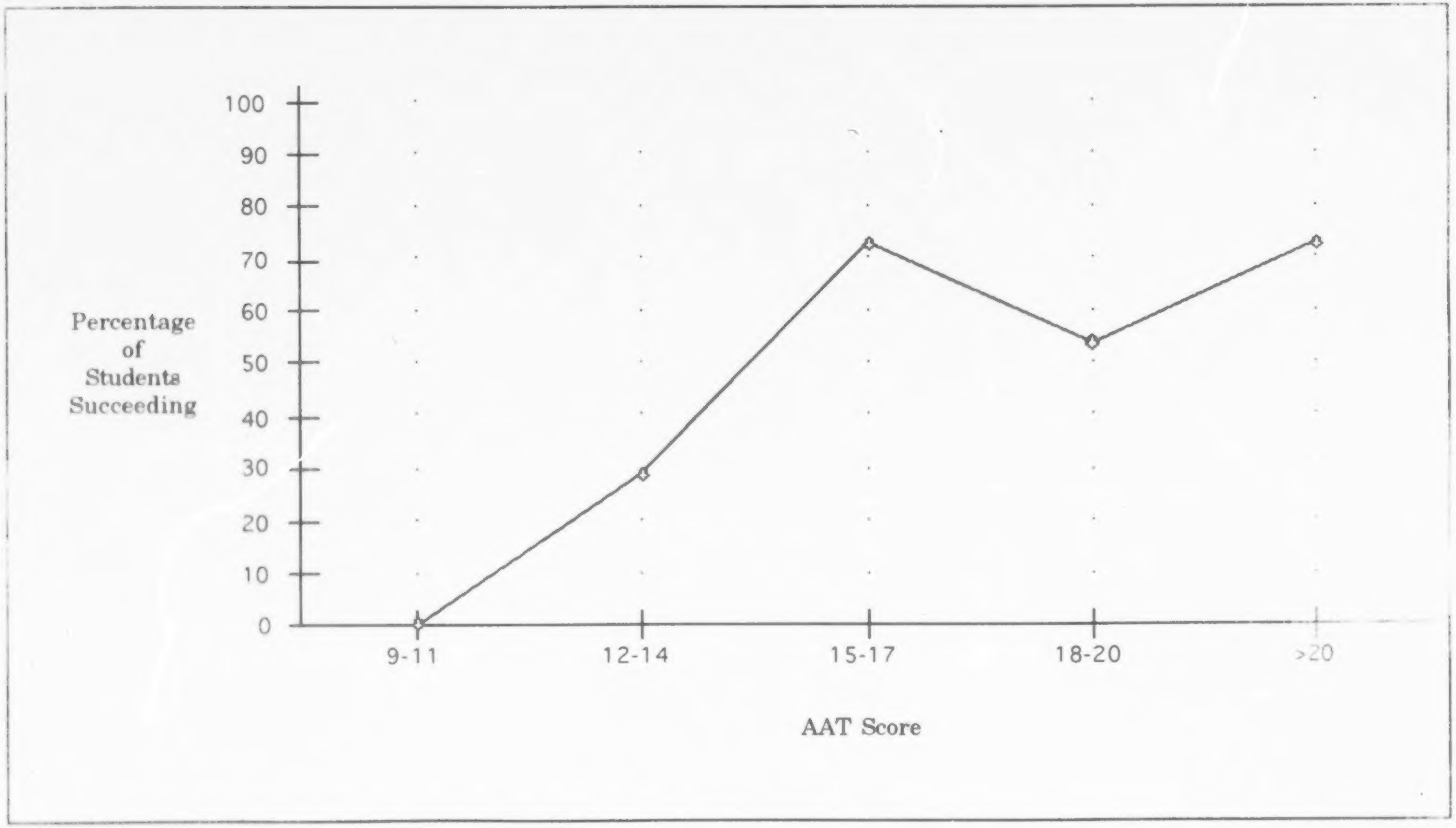

Figure 46. Percentage of All Students Passing (Drop=Fail) at Technical College #5, Grouped by AAT Score

Technical College #6

Descriptive Statistics

21 students participated. There were 18 (86%) successful completions, 0 (0%) failures, and 3 (14%) drops. This success rate is much higher than is typical for other institutions in the study (see Table 1, p. 64). Final grades were turned in as letter grades and had to be converted to corresponding percentage grades. This less precise data no doubt weakened some of these analyses. Of those completing the course, the mean grade was 86.7, with a standard deviation of 6.9, while the median was 85. The final exam was taken only by one section of seven students. The mean was 78.5 with a standard deviation of 14.5, while the median was 76. On the AAT, the mean grade was 12.1 with a standard deviation of 4.9, while the median was 12. These averages are all fairly typical of other institutions in the study (see Table 2, p. 65).

Correlational Analyses

The correlation of the AAT score to the final grade was $r=-.10$. This score is not statistically different from $r=.35$ ($z=-0.93$, $p>.05$). Therefore null hypothesis $H_0 1$ can not be rejected for this institution. The correlation of the AAT score to the final exam grade was $r=.41$. This score was also not statistically different from $r=.35$ ($z=0.142$, $p>.05$). Therefore null hypothesis $H_0 2$ can not be rejected for this institution.

Optimal Cut-Score Analysis

Determining a cut-score is not reasonable for this institution. Literally every student who finished the course did so successfully. Counting drops as failures, the success rate was 86%. No cut-score would improve on this prediction rate. With only three students dropping, it is hard to determine any meaningful data. The same is true when trying to establish a grey zone- no such meaningful one exists. Even increasing the definition of success to a more meaningful figure such as 85% yields no significant information. The size of the sample, the lack of any failing grades, and the compactness of the range of final grades all play a part, no doubt, but there is little reason to believe that the AAT test would do a good job at separating students at this institution. However, any cut-score chosen will technically result in more than a 67% prediction success rate as set forth in this study. This fact, however, has no meaningful interpretation.

AAT's Potential as a Placement Test at Technical College #6

The AAT does not seem to be an effective placement tool for this institution. Although due in some part to a compact and narrow range of final grade values, there seems to be no connection between the AAT score and final grades (see Figure 48). There does, however, seem to be a correlation between the AAT and final exam grades (see Figure 49), but with the extremely small sample size it is difficult to draw any conclusions. The limited size of the sample may have been a large factor, but the characteristic rise in final grades does not appear to occur as AAT scores rise (see Figure 50). The success rate of students, when one considers drops as equivalent to failures, also seems to have no relationship to the AAT (see Figure 51). Finally, with so few drops and no failures, it is hard to judge if the AAT could be used as a tool to separate likely successes from likely failures (see Figure 52).

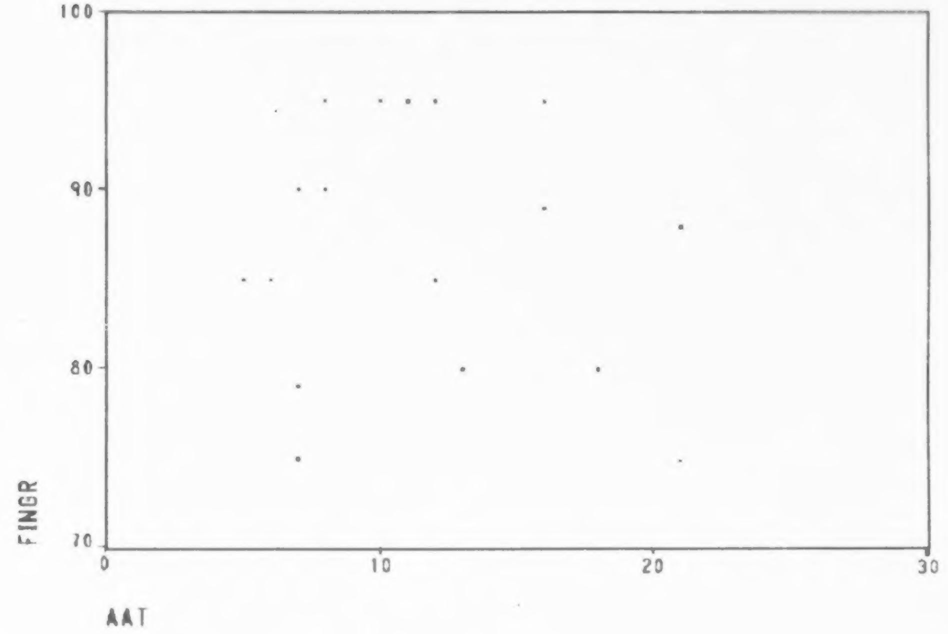

Figure 48. Scatter Graph of AAT Scores and Final Grades at Technical College #6.

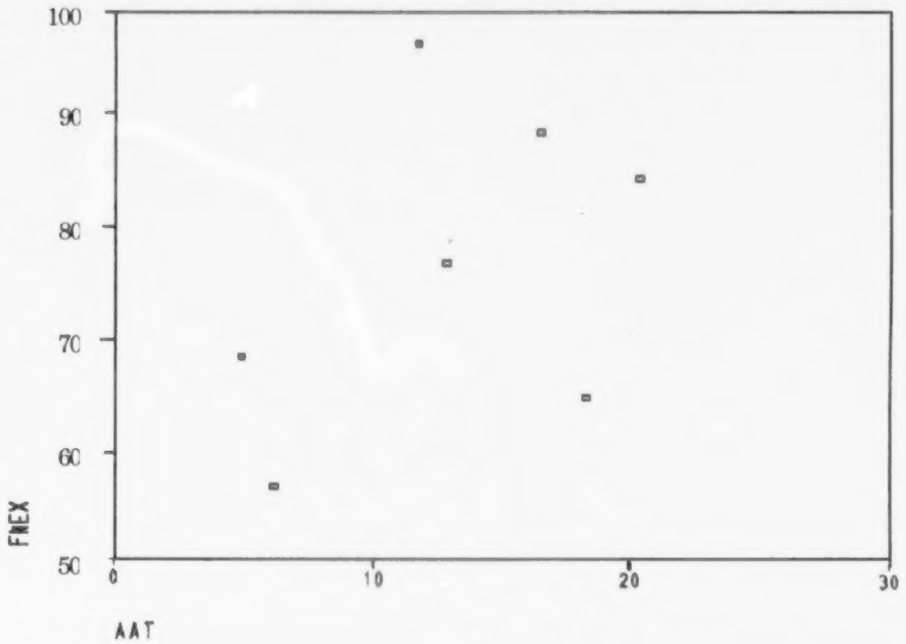

Figure 49. Scatter Graph of AAT Scores and Final Exam Grades at Technical College #6.

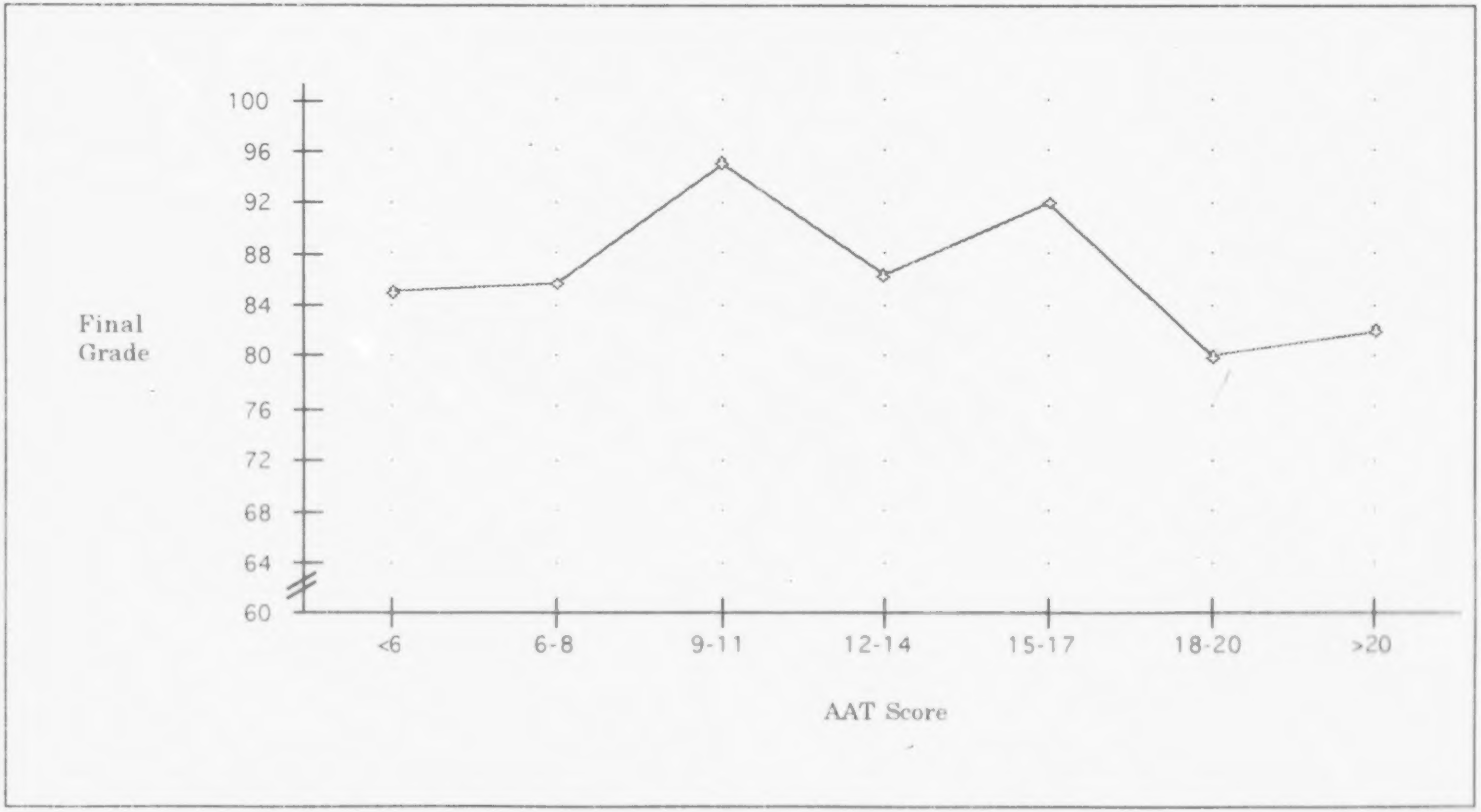

Figure 50. Mean Final Grades of Technical College #6.

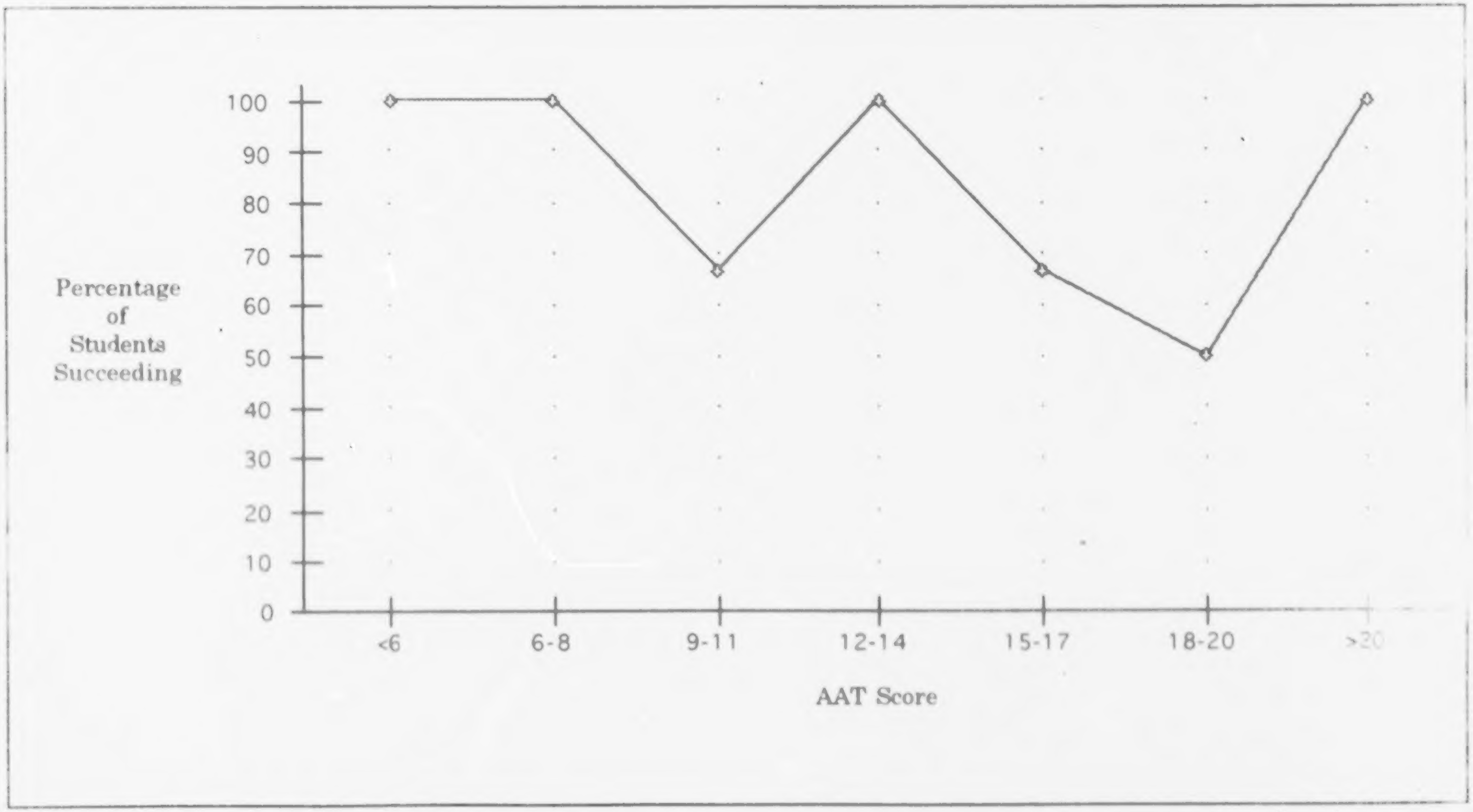

Figure 51. Percentage of All Students Passing (Drop=Fail) at Technical College #6, Grouped by AAT Score.

180

179

Analysis Across All Institutions

Descriptive Statistics

A total of 415 students participated in this study. There were 251 (60%) successful completions, 58 (14%) failures, and 106 (26%) drops (see Table 1, p. 64). Of those completing the course, the mean grade was 81.1, with a standard deviation of 14.0, while the median was 84. On the final exam, the mean was 77.0 with a standard deviation of 17.2, while the median was 80. On the AAT, the mean grade was 13.2 with a standard deviation of 5.2, while the median was 13 (see Table 2, p. 65). In doing all analyses across all institutions, a translation was done on Technical College #3's data because the grading scale at this institution was different than the grading scale at all other institutions (see Table 11, p. 99). A corresponding grade (on the 90-80-70-60 scale) was calculated using proportions for each individual grade on the grade scale of Technical College #3. The following translation approximates these points:

$$T_3 = 100 - 1.15(100 - G_3)$$

where T_3 is the translated score for a Technical College #3 participant's given score G_3.

Correlational Analyses

The correlation of the AAT to the final grade was r=.41; this is not statistically different from r=.35 (z=1.242, p>.05). Therefore the null hypothesis, as set forth in $H_0 3$ of this study, can not be rejected. The correlation of the AAT score to the final exam grade was r=.45, which is significant (z=2.061, p<.05). Therefore the null hypothesis, as set forth in $H_0$4 of this study, is rejected.

Optimal Cut-Score Analysis

In this study, 60% of all students pass their courses. The optimal cut-score when one counts drops as failures is 11 or 12, resulting in correct predictions 67% of the time. Among completers in the study, 81% succeed. The optimal cut-score when looking only at completers is 6, resulting in correct predictions 82% of the time. In both cases, the performance of the AAT also surpassed random chance (see Table 27). Both of these meet the minimum criteria of 67% as set forth in this study.

Table 27.

Optimal AAT Cut-Scores (Across All Institutions).

	Optimal Cut-Score	% of Correct Predictions	Random % of Correct Predictions	Cohen's Kappa
Completers	6	82%	76%	.26
All Participants	11	67%	54%	.29
	12	67%	52%	.31

When looking at all scores, the optimal grey zone appears to be in the 12-14 point range. If we use this as the grey zone, the success rate for students above this zone (AAT>14) is 94% among completers and 76% if one counts drops as failures. Students scoring less than 12 points on the AAT (those students below the grey zone) and completing the course have a 61% success rate. If one includes drops as failures, the success rate in this group drops to 42% (see Table 28).

Table 28.

Overall Success Rates Across All Institutions

AAT Score Range	Drop=Fail	Completers Only
<12	42%	61%
12-14	65%	90%
>14	76%	94%

The AAT's Potential as a Placement Test

Overall the AAT seems to be a reliable placement test. There is a definite and solid correlation between the AAT and final grades. There is a steady and nearly constant rise in the final grades corresponding to a rise in AAT scores (see Figure 53). Note that with the entire sample in place, the peaks and valleys of each individual analysis have entirely disappeared. The value of the instrument is also apparent when looking at successful completion rates (see Figure 54). When one counts drops as failures, the success rate for those students below the grey zone (AAT<12) is quite low, those students in the grey zone (AAT=12-14) somewhat better, and those above the grey zone (AAT>14) the best. The difference in success rates among those students completing the course is also quite apparent (see Figure 55). Finally, and pragmatically most importantly, the AAT seems to do an excellent job of separating likely successes from likely failures (see Figure 56).

Overall the AAT seems to be an excellent placement instrument. It was hoped at the outset that the AAT would have a correlation of $r=.35$ in relation to the final grade. This was the null hypothesis in each analysis. A failure to reject would mean that the correlation did not significantly differ from that expectation of $r=.35$. In individual institutional analyses, the null hypothesis $H_0$1 was rejected in only one case (Math119 at Technical College #5). In this instance, the null was rejected because it was shown to have a correlation factor which was significantly higher than $r=.35$ ($p<.05$). In the study-wide analysis, $H_0$3 also failed to be rejected, indicating the correlation of the AAT to final grade across all institutions did not differ significantly from $r=.35$ ($p>.05$).

It was hoped from the outset that the AAT would have a correlation of $r=.35$ in relation to the final exam grade. This was the null hypothesis in each analysis. A failure to reject would mean that the correlation did not significantly differ from that expectation of $r=.35$. In individual institutional analyses, the null hypothesis $H_0$1 was rejected in only two cases (Math119 at Technical College #5 and the overall analysis at Technical College #2). In these instances, the null was rejected because they were shown to have correlation factors which were significantly higher than $r=.35$ ($p>.05$). In the study-wide analysis, $H_0$4 also was rejected

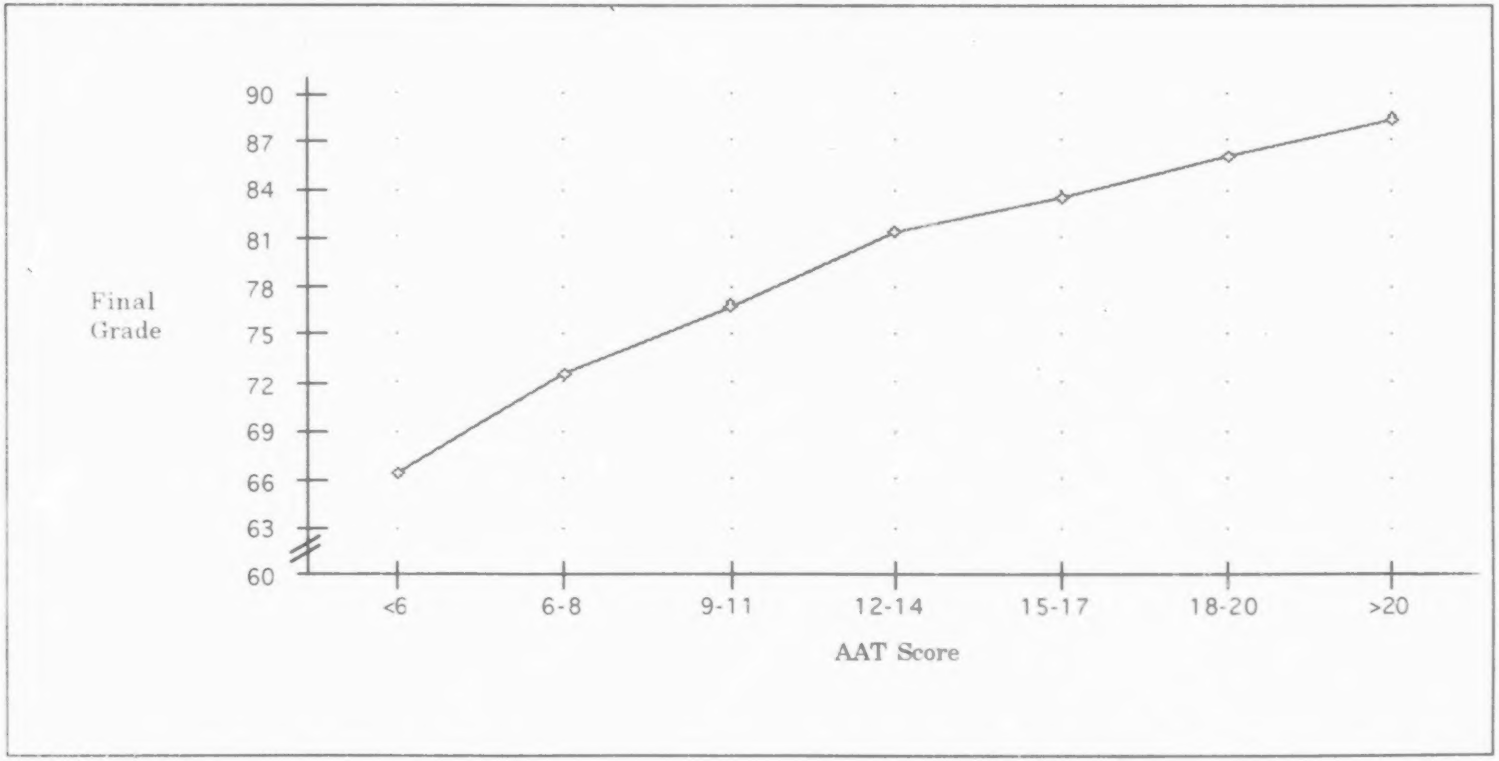

Figure 53. Mean Final Grades of All Students in the Study, Grouped by AAT Score.

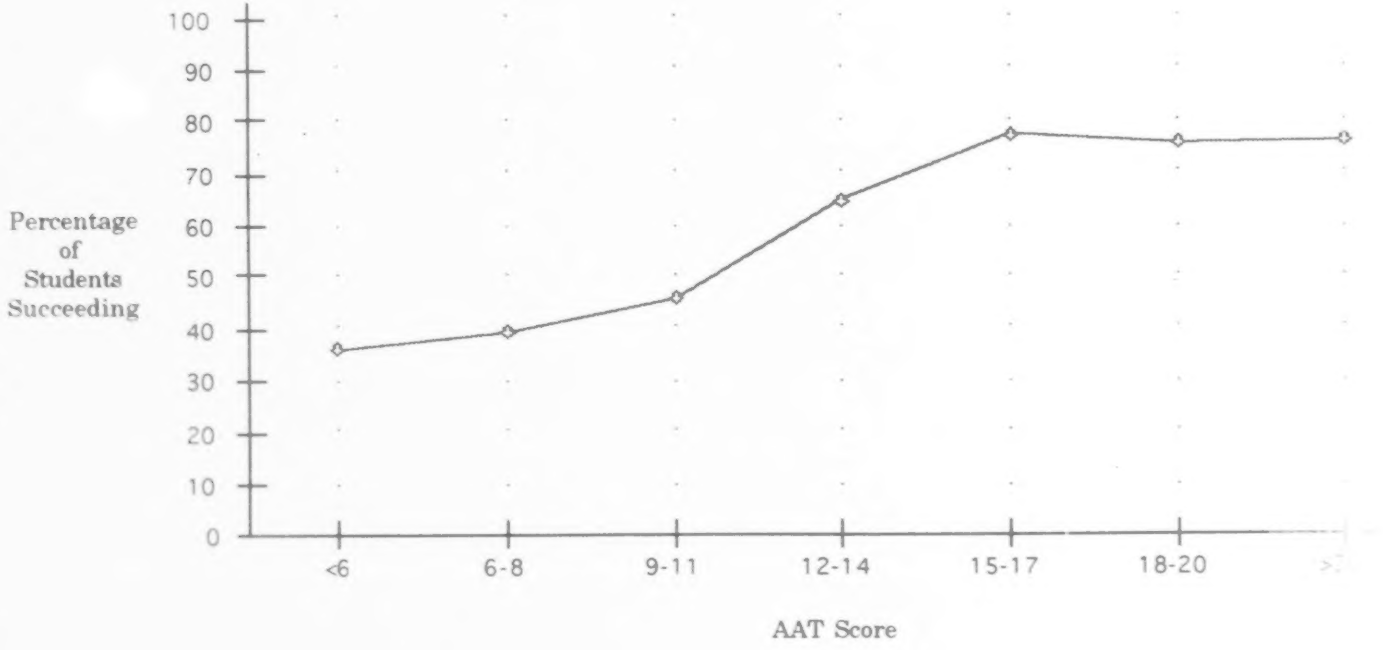

Figure 54. Successful Completion Rates of All Students in the Study (Drop=Fail).

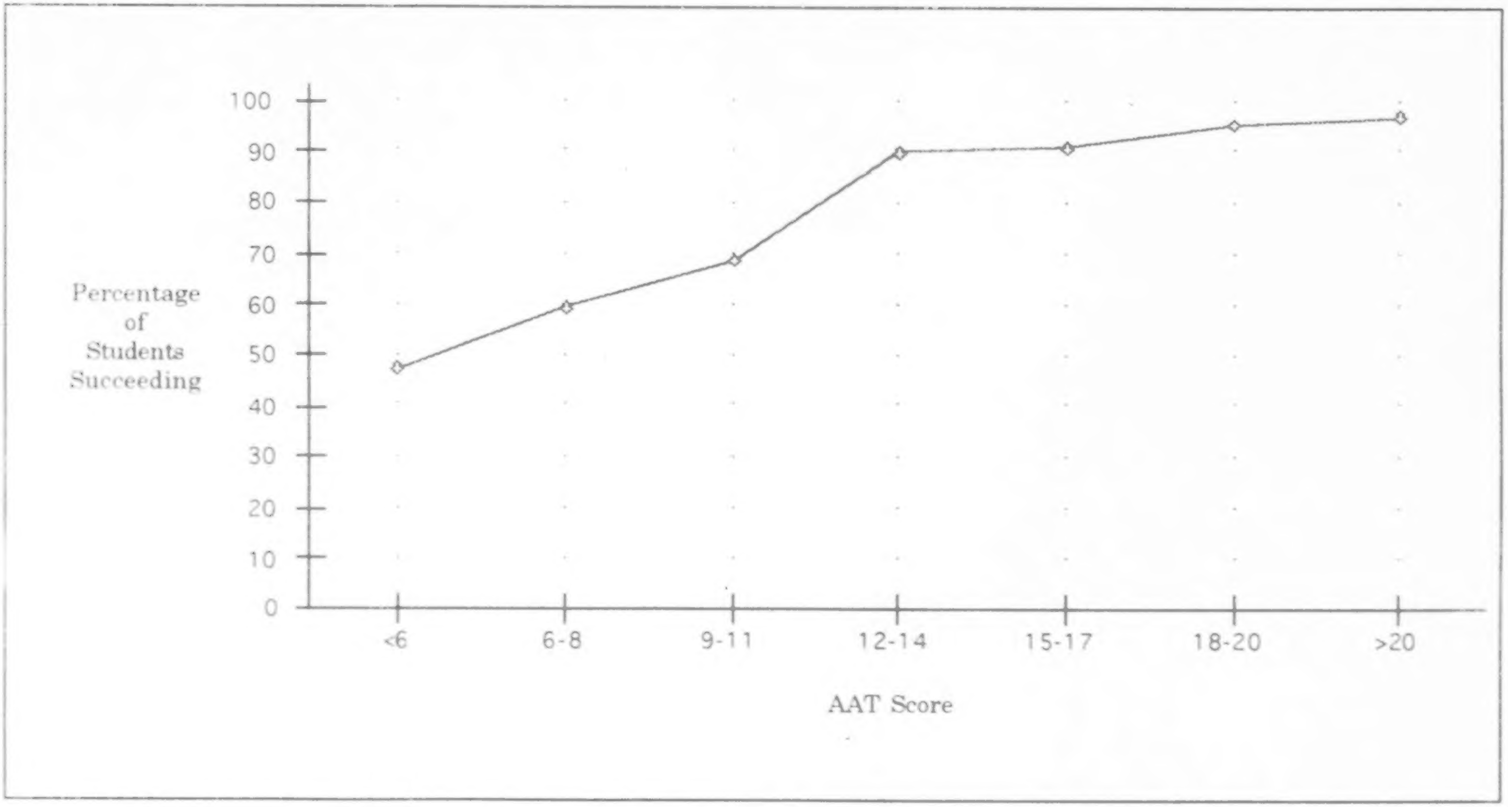

Figure 55. Success Rates Among All Completers in the Study.

because the correlation factor of the AAT to the final exam was shown to be significantly higher than the standard of r=.35 (p<.05).

It is also interesting to note that using the AAT with optimal cut-scores usually did result in a prediction success rate higher than the existing success rate. The effectiveness and meaningfulness of these cut-score depended upon whether drops were included in the analysis. Using only completers in this study usually resulted in cut-scores in the 6-10 range, with 8 being the mode (see Table 29). Random guessing has a mathematical expectation of 5. Scoring an 8 could have been the result of knowing the answers to only a few questions or the result of good guessing-not a very meaningful score. On the other hand, unlike the ASSET (ACT, 1994), using these scores did not result in prediction success rates that were appreciably lower than the existing success rates. In only two institutions (Technical College #3 and Technical College #5) was the existing success rate even slightly higher than the optimal prediction success rate using the AAT. Furthermore, raising the definition of success in these institutions to a final grade of 85% improved the comparison (see Table 30). Many institutions may also find that using a more meaningful cut-score in the 12-14 range still yields results which may be satisfactory (see Table 31).

When drops were included as failures, the optimal cut score always resulted in a higher prediction success rate (see Table 32). Please note that Technical College #6 is not included in these discussions as the data did not lend itself to any type of cut score. In the case of Technical Colleges #1, #2, and #3, 14 is the optimal cut score mentioned for all three institutions. This is a higher than average AAT for any of these institutions, therefore a significant number of students would be blocked from taking the course were this cut score to be implied. Doing so results in a prediction success rate which is at least 15 percentage points higher than the existing success rate. The results for Technical College #4 and Technical College #5 were satisfactory, but not as strong. The increase at Technical College #4 in particular is minimal, and the optimal cut-scores are still quite low for

Table 29.

Existing Success Rates and Prediction Success Rates for Optimal Cut Scores (Completers Only)

	Existing Success Rate	Optimal Cut-Score	Prediction Success Rate With Optimal Cut-Score
Technical College # 1	71%	8, 9, 10	78%
Technical College # 2	69%	8	82%
Technical College # 3	76%	6, 7, 8, 9	73%
Technical College # 4	88%	6	88%
Technical College # 5	89%	14	87%
Overall (Tech Coll #6 Removed)	80%	7, 8	81%

Table 30.

Existing Success Rates and Prediction Success Rates Using 85% as the Definition of Success (Completers Only)

	Existing Success Rate	Optimal Cut-Score	Prediction Success Rate With Optimal Cut-Score
Technical College # 3	62%	6, 13	65%
Technical College # 5	69%	14	74%

Table 31.

Existing Success Rates and Prediction Success Rates for Best Cut Scores in 12-14 Point Range (Completers Only)

	Existing Success Rate	Optimal Cut-Score	Prediction Success Rate With Optimal Cut-Score
Technical College # 1	71%	12	73%
Technical College # 2	69%	14	74%
Technical College # 3	76%	12, 13, 14	67%
Technical College # 4	88%	12	74%
Technical College # 5	89%	14	87%
Overall (Tech Coll #6 Removed)	80%	12	75%

both institutions. However, raising the definition of success at Technical College #4 and Technical College #5 to 85% yielded the desired results and made the contrast more impressive (see Table 33). Finally, in the analysis of every individual institution's grey zones, there was always a larger difference between the *below* group and the *above* group when comparing results if drops were included in the success rates (see Table 34). Including drops in the analysis would seem to: 1) yield higher, more meaningful cut-scores; 2) result in prediction success rates which are higher than existing success rates; 3) result in a greater disparity of success rates between those above the grey zone and those below the grey zone. As a practical matter, then, it is recommended that those who use this test in the placement of students should consider all the data obtained, not just data from the completers.

Table 32.

Existing Success Rates and Prediction Success Rates for Optimal Cut Scores (Drop=Fail)

	Existing Success Rate	Optimal Cut-Score	Prediction Success Rate With Optimal Cut-Score
Technical College # 1	52%	11,14	67%
Technical College # 2	53%	14	76%
Technical College # 3	56%	13,14	71%
Technical College # 4	75%	6	78%
Technical College # 5	59%	15	70%
Overall (Tech Coll #6 Removed)	60%	11,12	68%

Table 33

Existing Success Rates and Prediction Success Rates Using 85% as the Definition of Success (Drop=Fail)

	Existing Success Rate	Optimal Cut-Score	Prediction Success Rate With Optimal Cut-Score
Technical College #4	53%	13	65%
Technical College #5	47%	20	66%

Table 34.

Success Rates of Those Above and Below Grey Zones

		Completers Only		Including Drops	
		% Succeeding		% Succeeding	
	Optimal Grey Zone	Above Grey Zone	Below Grey Zone	Above Grey Zone	Below Grey Zone
Tech Coll #1	12-14	95	56	78	35
Tech Coll #2	11-13	90	42	83	26
Tech Coll #3	11-12	100	57	86	39
Tech Coll #4	7-10	96	67	87	50
Tech Coll #5	16-19	89	63	68	31
Overall	12-14	93	57	77	39

Note. Overall analysis does not include Tech Coll #6.

There are, however, other compelling reasons to include students who drop in the analysis. First, a drop can never be called a success. The fact that the number of drops is distinctively higher among those students measured as poorer by the AAT seems to indicate that many (if not most) of these drops were due to academic difficulties. Although these data are not as clean as failures, they should not be ignored. Consider also the very low failure rate among students. Overall only 14% of students actually failed a course, while nearly twice that many (26%) dropped. Ignoring this large number of students, and basing cut-score decisions on a small percentage, makes little sense.

Chapter 5

Summary and Recommendations

Summary

The purpose of this study was to create a tool which could be used by two-year technical colleges to assist in the placement of entering students into the mathematics curriculum as accurately as possible, and specifically to determine their readiness for entry-level algebra. To insure that the test be as beneficial as possible, two benchmarks were established. First, the test needed to have a correlation of at least r=.35 when compared to entry-level course work. Second, the need to demonstrate the ability to predict the probability of success with at least a 67% accuracy rate. As was stated earlier, the figure of r=.35 was chosen because it is the benchmark used by California's two-year colleges and because this score is higher than that reported for the ASSET test. The benchmark of 67% was chosen because this score exceeded percentage rates found in similar studies utilizing the ASSET Test.

It was hoped that these qualities would hold true not only for individual institutions, but across all participating institutions. This would give these schools normative information from similar institutions with which to compare their results. It was also hoped the study would provide any institution wishing to adopt the AAT not only general information about the AAT, but also important and pragmatic specifics such as assistance in determining what cut-scores to adopt for first time usage. To a large extent, the study was successful in all these goals. The specific research questions and the results follow.

Question #1. Is the correlation between the AAT and the final average grade of students in entry-level algebra courses across the same institution equal to or greater than r=.35?

In one case the correlation was shown to be significantly greater than r=.35 (p<.05). There is good reason to believe that with larger sample sizes more of the results may also have been statistically significant. In all other cases there was no statistical difference between the correlation found and r=.35 (p>.05). The median correlation of the AAT to the final grades in the individual courses was r=.48; the median correlation of the AAT to the final grades at the different participating institutions was r=.44 (see Table 35). These results compare favorably to similar results found for other placement tests.

Question #2. Is the correlation between the AAT and the final exam grade of students in entry-level algebra courses across the same institution equal to or greater than r=.35?

In two cases the correlation was shown to be significantly greater than r=.35 (p<.05). There is good reason to believe that with larger sample sizes more of the results may also have been statistically significant. In all other cases there was no statistical difference between the correlation found and r=.35 (p>.05). The median correlation of the AAT to the individual courses was r=.49; the median correlation of the AAT to the final grades at the different participating institutions was r=.45 (see Table 36).

Table 35.

Correlation of the AAT to Final Grades in Individual Courses and at Individual Institutions

Technical College/Course	r
Technical College #1	.45
Technical College #2 (Math040)	.52
Technical College #2 (Math045)	.61
Technical College #2 (Overall)	.56
Technical College #3	.57
Technical College #4	.39
Technical College #5 (Math119)	.74*
Technical College #5 (Math117)	.19
Technical College #5 (Overall)	.43
Technical College #6	-.10

Note. *This score found to be statistically greater than r=.35.

Table 36.

Correlation of the AAT to Final Exam Grades in Individual Courses and at Individual Institutions

Technical College/Course	r
Technical College #1	.44
Technical College #2 (Math040)	.53
Technical College #2 (Math045)	.65
Technical College #2 (Overall)	.60*
Technical College #3	.58
Technical College #4	.28
Technical College #5 (Math119)	.78*
Technical College #5 (Math117)	.13
Technical College #5 (Overall)	.46
Technical College #6	.41

Note. *Only scores found to be statistically greater than r=.35.

Question #3. Is the correlation between the AAT and the final average grade of students in entry-level algebra courses across all institutions equal to or greater than r=.35?

The correlation of the AAT to the final grades of all participants in the study was r=.41. This score was not significantly greater than r=.35 (p>.05), but the availability of only a moderately-sized sample may have been responsible. This result compares favorably to results from other placement tests. Showing that the test correlated well across all institutions was important for two reasons. First, it gives individual institutions normative data across similar institutions which may be used for comparative analyses. Second, it implies that these results may be able to be extrapolated to other similar institutions.

Question #4. Is the correlation between the AAT and the final exam grade of students in entry-level algebra courses across all institutions equal to or greater than $r=.35$?

The correlation of the AAT to the final exam grades of all participants in the study was $r=.45$. This score was found to be significantly greater than $r=.35$ ($p<.05$). Showing that the test correlated well across all institutions was again important for two reasons. First, it gives individual institutions normative data across similar institutions which educators may use for comparative analyses. Second, it implies that these results may be able to be extrapolated to other similar institutions.

Question #5. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67% or higher) when non-completers are ignored (across all introductory algebra classes in the same institution)?

In every institution, with only completers included in the analysis, the prediction success rate was at least 73% (see Table 29, p. 167). The median prediction success rate was 85%. In four of the six institutions this was an improvement over the existing success rate. In the two institutions where it was not, the prediction success rate was only two to three percentage points below the existing success rate. The median existing success rate was 82%. Even relatively high cut scores in the 12-14 point range resulted in prediction success rates which were approximately the same as the existing success rates at those institutions, only in Technical College #6 was this not the case. These results compare quite favorably to similar results found for other placement tests.

The test also performed quite well when using a grey zone (see Table 37). The median pass rate above the grey zone was 95%; the median pass rate below the grey zone was only 57%. The two regions (above and below the grey zone) are separated by only a few points and the majority of students fall clearly into one zone or the other. This is important because the test is of maximum benefit to those students who fall clearly into one zone or the other.

Table 37.

Success Rate of Completers Above and Below the Grey Zone at Individual Institutions

Institution	Above the Grey Zone	Below the Grey Zone
Technical College #1	95%	56%
Technical College #2	90%	42%
Technical College #3	100%	57%
Technical College #4	96%	67%
Technical College #5	89%	63%

Note. Technical College #6 is not included as all participants passed.

Question #6. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67%) when non-completers are included (across all introductory algebra classes in the same institution)?

In every case the optimal cut score resulted in prediction success rates which were at least 67% (see Table 32, p. 169). The median prediction success rate was 77%. In every case the prediction success rate was greater than the existing success rate (except for Technical College #6 where no meaningful cut score existed). The median existing success rate was 58%. These results compare quite favorably to similar results found for other placement tests. As it is recommended that one include drops in all analyses, it is crucial that the implementation of cut scores under these conditions improve the existing success rate. It is also important to note the optimal cut scores mostly fell in the 11-15 point range. These scores are higher than a significant percentage of students scored, meaning that their implementation would likely prevent large numbers of unprepared students from entering an algebra course they were unprepared for.

The test also performed quite well when utilizing a grey zone (see Table 38). The median pass rate above the grey zone was 83%; the median pass rate below the grey zone was only 35%. Again, the two regions (above and below the grey zones) were separated by only a few points and the majority of students placed into one or the other of the two groups. This in turn means that most students would gain the maximum benefit from their participation in a placement process that included the AAT.

Table 38.

Success Rate of All Students Above and Below the Grey Zone at Individual Institutions

Institution	Above the Grey Zone	Below the Grey Zone
Technical College #1	78%	35%
Technical College #2	83%	26%
Technical College #3	86%	39%
Technical College #4	87%	50%
Technical College #5	68%	31%

Note. Technical College #6 is not included as all participants passed and only 3 students dropped.

Question #7. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67% or higher) when non-completers are ignored (across all institutions in the study)?

The prediction success rate was 81% for all students. This was a slight improvement over the existing success rate of 80% for all students. As the test succeeded across all institutions and also improved upon the existing success rate, this provides good normative data for institutions in the study. In addition, it also provides information to similar institutions which may wish to implement the test in the future.

The test performed quite well across all institutions when utilizing a grey zone as well. The grey zone study-wide was 12-14 points. The pass rate for those completers above the grey zone was 93%; the pass rate for those below the grey zone was only 57%. Once again this provides useful normative information for participating institutions, as well as valuable information for any similar institution wishing to adopt the AAT as a possible placement instrument.

Question #8. Is the AAT able to separate the likely failures from the likely successes (with an accuracy rate of 67%) when non-completers are included (across all institutions in the study)?

The prediction success rate was 68% for all students. This was distinctly higher than the existing success rate of 60% for all students. The optimal cut score overall was 11 or 12. It would appear that if these cut scores were applied at most institutions involved in the study, that a significant number of unprepared students would be prevented from enrolling in an algebra class for which they are unprepared. There is also reason to believe that one might extrapolate these results to other similar institutions.

The test again performed well when using a grey zone to interpret placement. Those above the grey zone succeeded in 77% of the cases, while those below succeeded in only 39%. Once again this provided useful normative information for the participating institutions. The same information would of course be useful to any similar institution wishing to adopt the AAT as a placement instrument.

Final Overview

The test performed quite well both in terms of the correlations found and the rate of successful predictions when utilizing optimal cut scores.

The test seemed to work especially well in institutions where the success rate in entry-level algebra courses was under 75%. Although the analyses were often based on small sample sizes, the results were fairly consistent and impressive. The overall results seem to indicate the possibility that the test may perform quite adequately at institutions with similar characteristics as those participating in the study.

Areas for Future Research

The reasons students drop.

Exploring the nature of drops in relationship to placement could provide some useful information. It is interesting to note that while the success rates among completers consistently rise as the AAT rises, the success rate among all students takes a slight dip in the highest two scoring ranges (see Figure 54, p. 162 and Figure 55, p. 163). This is because of the higher drop rate among the students whose AAT scores are in these highest two ranges. One could surmise that perhaps some these students realized they were placed too low and dropped the course in order to pursue a different option. Or it might be possible that these students were bored with a course that seemed too easy for them. Many educators at the high school level believe that the drop out rate among gifted students is higher than the rate of the student body as a whole. This could be a similar phenomenon. If another study were to be conducted, it would be interesting to determine why students dropped the course. The assumption of this study is that a drop is usually a failure, but there are many reasons why a student drops a course. Isolating those drops where students are truly failing from those dropping for other reasons could fine tune the results of this study, perhaps resulting in a better instrument or at least better interpretations of the results. Such a study might also reveal if students at different ability levels drop for different reasons and perhaps address the individual needs of each group.

Exploring student motivation.

Another interesting phenomenon of this study is that the students in the lowest group (AAT < 6) often outperform students in the group just higher (AAT=6-8). This creates the appearance of a tail on some of the graphs (e.g. Figure 3, p. 70 and Figure 5, p.72). As stated many times earlier, it seems there are always a few students who do not truly try their best on the test. Merely answering randomly to the questions results in an average of 5 correct answers. As students had nothing to gain from either a good or a bad performance, there was no motivation to succeed. It seems apparent that a somewhat sizeable contingent gave little or no effort to the test and of course performed quite low. Subsequently, however, being better students than their low scores would indicate, they scored well in the course. There is no doubt that these scores had a negative impact on the results of this study. They decreased the correlation coefficient and raised the averages and success rates of the lower groups of students. If this test were actually put into use by an institution, the motivation of students to succeed on the test would obviously increase, and it is probable that the effectiveness of the test would as well. In future studies it would be interesting to test the effect of motivating factors. A researcher could build into the study something that would motivate students to give their best effort and observe the effects.

Technical College #5: A special case.

Students at Technical College #5 were obviously different from the norm in that they had a distinctly higher average on the AAT test, and this presumably hurt the ability of the test to assist in predicting grades. At present, the scores students from Technical College #5 achieve on the test are not disparate enough to best discern which students are most prepared to benefit from the course. While the average AAT scores of the other schools all fall in a rather narrow range from 11.57 to 12.88, the average AAT at Technical College #5 is 18.5. Loosely translated, this means that students at Technical College #5 miss half of the problems that all other students do. Thus being the case, there are many AAT questions answered by too large a percentage of the students at Technical College #5, thus limiting their usefulness.

However, the AAT has obvious value to this institution. While the desired effects are present, more disparate scores should raise the value of the test as a placement tool. Further analysis, similar to that done in the original design of the test, might yield valuable information which could be used to improve the test's performance at this institution and perhaps at similar institutions with students of above average arithmetic capabilities.

The questions which best separate the failures from successes could be identified and built on. Further research might be able to isolate the most effective questions for this particular institution and expand on them, thereby increasing the range of scores, giving more detail, and resulting in a more effective placement instrument.

Use of the AAT outside of Ohio.

The test worked well at the majority of technical colleges which participated in this study. As these institutions represent more than half of Ohio's technical colleges, it seems reasonable to believe that the test would perform well at any similar institution that has a failure and drop rate they would like to lower. It would be interesting to see if the test would perform as well at other institutions in other states with similar academic philosophies and problems.

Note to Schools which Might Use the AAT as a Placement Instrument

The best course for any institution considering the AAT for use as a placement test would be to run an institution-wide in-house study following procedures similar to the ones outlined in this paper. If this is not practical, a committee should first define what is to be considered as a successful conclusion, then decide upon an acceptable success rate for their students based on this definition. It is recommended that institutions putting this placement test into use first make use of the 12-14 *grey zone* and then examine their own results. This was the best grey zone for the overall analysis, and most of the individual schools' optimal grey zones were close to this as well. Once a grey zone has been determined, the test should be administered and the results analyzed. If students in the grey zone perform better than expected in the class, then the grey zone is too high, and the converse is true as well. Students in the regions above and below the grey zone should be examined in a similar manner. Obviously, there should be a sharp contrast between these groups, and adjustments should be made accordingly.

Bibliography

Ahrendt, Kenneth M. (1987). Teaching the developmental education student. New Directions for Community Colleges, 15(1). (Eric Document Reproduction Service No. ED 280519).

Akst, G., & Hect, M. (1980). Program evaluation. In A. S. Trillin and Associates (Eds.), Teaching Basic Skills in College (pp. 261-296). San Francisco: Jossey-Bass.

Akst, Geoffrey, & Hirsch, Lewis. (1991). Selected studies on math placement. Review of Research in Developmental Education, 8(4). (Eric Document Reproduction Service No. ED 354 964).

Angel, Dan. (1990). Texas Academics Skills Program. Capsule 3(3), 10-15.

Ansley, Abraham A. (1991). They came to college. A remedial/developmental profile of first-time freshman in SREB states. Issues in Higer Education, #25. Southern Redgional Education Board. (Eric Document Reproduction Service No. ED 345 617).

Barr, Robert, & Parker, Annette. (1989). Mathematics student outcomes study, year three. Final report. Learning Assessment Retention Consortium of the California Community Colleges. (Eric Doucment Reproduction Service No. ED 321 782).

Belcher, Marcia. (1984). A cohort analysis of the relationship between entering basic skills and CLAST performance for Fall 1981 first time in college students. Miami-Dade Community College, Office of

Institutional Research. (Eric Document Reproduction Service No. ED 267 870).

Berk, R. A. (1986). A consumer's guide to setting performance standards. Review of Educational Research, 56(1), 137-172.

Borst, P. W. (1984). The skills prerequisite system at Fullerton College (a six-year investment in people). Fullerton, CA. North Orange County Community College District. (Eric Document Reproduction Service No. ED 255 247).

Bough, Karl. (1995). Developmental placement and academic progress: tracking "at-risk" students in the 1990 entering cohort. Enrollment analysis EA95-2. Prince George's Community College, Largo, MD. Office of Institutional Research and Analysis. (Eric Document Reproduction Service No. ED 377 908).

Bray, Dorothy. (1987). Assessment and placement of developmental and high-risk students. New Directions for Community Colleges, 57, Cohen, Arthur M. (Ed.), 33-47.

Chand, S. (1985). The impact of developmental education at Triton College. Journal of Developmental Education, 9(1), 2-5.

Clark, Burton R. (1960). The Open Door College: A Case study. New York: MacGraw-Hill.

College of the Canyons, Calencia, CA. Office of Institutional Development. (1994). Experience tables. Predictive validity studies, and validation of placement tables for the MDTP placement tests. (Eric Document Reproduction Service No. ED 376 916).

Conlin, Steven. (1989). Students bypassing remedial work and the effects on subsequent grades and dropout rate. (Eric Document Reproduction Service No. ED 317 240).

Cordrey, L. J. (1984). Evaluation of the skills prerequisite systems at Fullerton College (a two-year follow-up). Fullerton, CA: Fullerton College. (Eric Document Reproduction Service ED244663).

Cox, Mary Ann. (1985). California community colleges as providers of remediation. Learning Assessment Retention Consortium of the California Community Colleges. (Eric Document Reproduction Service No. ED291446).

Dodson, Ronald K. (1987). Quality and accessability: are they mutually exclusive? Community College Review, 14(4), 56-60.

Ebel, R. L., & Frisbie, D. A. (1991). Essentials of Educational Measurement (5th Edition). Engelwood Cliffs, NJ: Prentice-Hall.

Educational Testing Service. (1990). The State of Mathematics Achievement. Washington, D.C.: U.S. Department of Education, Office of Educational Research and Improvement.

Einspruch, Eric, & Downing, Sherry. (1990). Entry-level testing results for all credit students enrolled at Miami-Dade Community College during Fall Term 1989. Miami-Dade Community Cllege, Fl. (Eric Document Reproduction Service No. ED 328 321).

Evangelauf, J. (1985). "Enrollment in remedial courses jumps at 63 percent of colleges that offer them." Chronicle of Higher Education, Feb. 13, 1985 3.

Feinberg, Lawerence. (4/29/84). Remedial work seen as erosion of education. Washington Post, p. 6.

Floden, Robert E., Porter, Ander C., Schmidt, William H. and Freeman, Donald J. Don't they all measure the same thing: consequences of standardized test selection. In Baker, Eva L. and Edys, S. Quellmalz (Eds.). (1980). Educational Testing and Evaluation. Beverly Hills, CA: Sage Publications.

Florida State Board of Community Colleges, Tallahassee, FL. (1994). Summative review of college and vocational preparatory instruction. (Eric Document Reproduction Service No. ED 370 651).

Gabe, L. C. (1989). Relating college-level course performance to Asset placement scores. (Institutional Research Report Abstract RR89-22). Fort Lauderdale, Fl: Broward Community College. (International Research Reprot Abstract RR89-22). (Eric Document Reproduction Service No. ED 309823).

Grable, J. R. (1988). Remedial education in Texas two-year colleges. Journal of Developmental Education 12(2), 2-5.

Hardin, Carlette J. (1988). Access to higher education: who belongs? Journal of Developmental Education, 12(1), 2-6.

Haase, M. H., & Caffrey, P. (1984). The impact of a coordinated assessment/placement process on student success and retention: statistical response to a grant proposal. Sacramento, CA: Sacramento City College. (Eric Document Reproduction Service No. ED 243 540).

Hector, J. (1984). Establishing cut-off scores for placement in community college developmental courses. Morristown, TN: Walters State Community College. (Eric Document Reproduction Service No. ED 246 934).

Hughes, Ronald Elliott, & Nelson, Carlene H. (1991). Placement scores and placement practices: an empirical analysis. Community College Review, 19(1), 42-46.

Isonio, Steven. (1992). Implementation and initial validation of the MDTP tests at Golden West College. (Eric Document Reproduction Service No. ED 345 782).

Jaschik, Scott (9/11/85). States questioning role of colleges in remedial study. Chronicle of Higher Education, 31(2), 1, 19-20.

Jenkins, Bess G. (1991). Meeting the diverse needs of two-year college students through appropriate course placement. Dallas, Tx: Paper presented at the Fall Conference of the North Texas Community/Junior college Consortium. (Eric Document Reproduction Service No. ED 341444).

Jones, Bruce D. (1991). Issues of mathematics placement and remediation in America's two-year colleges. An unpublished manuscript.

Jones, Bruce D. (1993). Entry level mathematics in the two-year college: an examination of testing and placement issues at Hocking College. An unpublished manuscript.

Laramie County Community College, Cheyenne, WY. (1995). Academic progress of developmental students, Fall 1993 - Spring 1995. (Eric Document Reproduction Service No. ED 386 236).

Lederman, Marie Jean, Ribaudo, Michael, & Ryzewic, Susan R. (1985). Basic skills of entering college freshman: a national survey of policies and perceptions. Journal of Developmental Education, 9(1), 10-13.

Losak, John. (1982). Retention patterns for full time first time in college students based on basic skills assessment performance. Miami-Dade Community College, Office of Institutional Research. (Eric Document Reproduction Service No. ED 226 784).

Losak, John, & Morris, Cathy. (1982). Retention, graduation and academic progress as related to basic skills. Miami-Dade Community College, Office of Institutional Research. (Eric Document Reproduction Service No. ED 226 784).

Lyons, J. Doyle. (1990). Success of community college students completing developmental courses. (Eric Document Reproduction Service No. ED 325 194).

McDonald, Anita D. (1988). Deveopmetal mathematics instruction: results of a national survey. Journal of Developmental Education, 12(1), 8-15.

McDonald, Anita D. (1989). Issues in assessment and placement for mathematics. Journal of Developmental Education, 13,(2), 20-23.

Maxwell, M. (1979). Improving Student Learning Skills. San Francisco, CA: Jossey-Bass.

Messick, S. (1989). Meaning and values in test validation: the science and ethics of assessment. Educational Researcher, 18(2), 5-11.

Miami-Dade Community College. (1984). 1984 Institutional self-study. Volume II: Prescriptive Education. (Eric Document Reproduction Service No. ED 259 770).

Michigan State Board of Education. (1990). A survey of student assessment and developmental education in Michgan's public community colleges. (Eric Document Reproduction Service No. ED 320624).

Mickler, Mary Louise, & Chapel, Ann C. (1989). Basic skills in college: academic dilution or solution? Journal of Developmental Education, 13(1), 2-4, 16.

Miles, Curtis. (1993). The fourth R: building standardized testing into thoughtful learning. Journal of Developmental Education, 16(3), 36-37.

Morante, E. A. et. al. (1982). Report to the board of higher education on results of the New Jersey college basic skills placement testing and recommendations on instruction and curriculum. Trenton, NJ: New Jersey Basic Skills Council, New Jersey State Board of Higher Education. (Eric Document Reproduction Service No. ED 232 716).

Morante, Edward A. (1986). The effectiveness of develpmental programs- a two-year follow-up study. Journal of Developmental Education, 9(3), 14-15.

Morante, Edward A. (1989). Selecting tests and placing students. Journal of Developmental Education, 13(2), 2-6.

Ohio Federation of Teachers Higher Education Committee. (1984). An important new book for community colleges serving at-risk students. Excellence, 6(3), 3.

Ohio Federation of Teachers Higher Education Committee. (1984). What's really wrong with public higher education. Excellence, 6(3), 2.

Oromaner, Mark. (1985). A retention study of entering students in basic skills courses and students in non-basic skills courses. Hudson County (NJ) Community College. (Eric Document Reproduction Service No. ED 257 537).

Pearse, C. A., Agrella, R. F., & Powers, S. (1982). Identification and placement of college students in developmental education programs. Paper presented at the 61st annual Meeting of the California Educational Research Association, Sacramento, CA. (Eric Document Reproduction Service No. ED 231 415).

Platt, G. M. (1986). Should colleges teach below college-level courses? Community College Review, 14(2), 19-25.

Plisko, V. W., & Stern, J. (1985). The condition of education: a statistical report. Washington, D.C.: National Center for Education Statistics. (Eric Document Reproduction Service No. ED 258 365).

Richardson, Richard C., Jr. (1983). Future of the open door: a presenation for ACCT. Paper presented at the Annual Convention of the

Association of Community College Trustees, Phoenix, Az. (Eric Document Reproduction Service No. ED 235 848).

Rogers, Glenn E., & Steinhoff, Carl R. (1991). Florida community colleges meet the challenge: preparing students for minimum competency testing. Community College Review, 18(4), 33-38.

Roueche, John E. & Archer, Patricia F. (1979). Entry level assessment in college. Community College Review, 6(4), 15-27.

Roueche, J. E., & Baker, G. A., III. (1986). The success connection: examining the fruits of excellence. Community, Technical, and Junior College Journal, 56(5), 47-54.

Rouche, John E., & Baker, George A. III. (1987). Access and Excellence. The Community College Press, Washington D.C.

Rouche, John E., Baker, George A. III., & Rouche, S. D. (1987). Open door or revolving door? Open access and the community college. Community Junior and Technical College Journal, 56(5), 22-26.

Roueche, John E., & Snow, Jerry J. (1978). The teacher and college remedial programs. Today's Education, 67(3), 69-72.

Rounds, J.C., & Anderson, D. (1985). Placement in remedial college classes: required vs. recommended. Community College Review, 13(1), 20-27.

Shaw, Philip in Henry, N. B. (Ed.). (1961). Development in and Through Reading: 60th Yearbook of the National Society for the Study of Education, Part 1. Chicago: University of Chicago.

Simmons, Ron. (1994). Precollege programs: a contributing factor to university student retention. Journal of Developmental Education, 17(B), 42-45.

Slark, Julie. (1991). RSC validation of mathematics placement tests. Research, planning, resource development report. Santa Ana, CA: Rancho Santiago Community College. (Eric Document Reproduction Service No. ED 341 418).

Stevens, James. (1992). Applied Multivariate Statistics for the Social Sciences (2nd Edition). Hillsdale, NJ: Lawrence Erlbaum Associates.

Sturtz, Alan J., & McCarroll, Judith A. (1993). Placement testing and student success: the first intervening variable. (Eric Document Reproduction Service No. ED 360018).

Sworder, Steven. (1990). An analysis of the relationship between student success and delayed entry into the mathematics curriculum following completion of the matriculation process at Saddleback College. (Eric Document Reproduction Service No. ED 318 514).

Wambach, Cathrine, & Brothen, Thomas. (1990). An alternative to the prediction-placement model. Journal of Education, Vol 13(3), 14-15, 24-25.

Wattenbarger, James L. & McLeod, Norman. (1989). Placement in the mathematics curriculum: what are the keys? Community College Review 16(4), 17-21.

Weber, J. & Twing, J (1986). Comparisons of methods for setting placement scores of entering college freshman. Paper Presented at the 67th

Annual Meeting of the American Educational Research Association, San Francisco. (Eric Document Reproduction Service No. ED 275 761).

Wierner, Harvey S. (1989). Evaluation assessment programs in basic skills. Journal of Developmental Education, 13(2), 24-26.

APPENDIX

Materials Used in the Study

April 16,1996

Dear Professor:

Like many technical colleges around the state, we at Hocking Technical College have been looking for a solution to our testing and placement problem in the area of mathematics. The literature suggests about half of America's two-year colleges use in-house tests while the other half use some sort of standardized placement test, with ASSET being the most common. But while standardized tests have not shown the strong correlations educators have hoped for, in-house tests have rarely been put through any statistical studies, and are rarely tested beyond the boundaries of the particular institution where they are used.

We currently use the numerical skills portion of the Asset Test, but have been less than satisfied with the results. Both our in-house studies and even ACT's own data suggest a lower correlation that what we would like. For the past 5 years we have been working to design and test a placement instrument of our own- the Arithmetic Achivement Test (AAT). In numerous studies the AAT has been shown to have a higher correlation to actual student performance than the ASSET test, and thus is a better predictor of student success. We would now like to test our placement instrument beyond the walls of our own institution. We are trying to pilot this test foremost at other technical colleges because we draw from a similar pool of prospective students and share the same basic goals and philosophies. We would like to have your entry level algebra students try our exam. It is a short exam that would take a class period or less to administer. We would then grade all-tests, correlate the results to actual student performance, giving you in return not only correlation factors but a detailed analysis. With other institutions participating you will also get standardized results from all participating technical colleges across our state. Finally, if you decide the test suits your needs as well as it has ours, you will have permission to use the test in the future. It is a simple multiple choice test which can be machine graded. In addition, I would be glad to offer any support your institution might need in case you did decide to adopt and use this instrument.

You should also know that not only has this been an ongoing project of personal interest, but has also become my dissertation project. I have included a stamped self-addressed envelope and interest survey and would appreciate an indication of your interest in this project. Thank you in advance for your kind attention and consideration of this endeavor. I look forward to hearing from you.

Sincerely,

Bruce Jones
Math Area Coordinator
Hocking Technical College
Nelsonville, OH 45764

AAT Interest Survey

Thank you again for your time and consideration. Let us stress that your commitment to this project would be a very minimal sacrifice of time. You would be asked to have your students take a 25 question multiple choice test which should take one class period (less in most cases). You would mail the answer sheets back to us. At the end of the quarter we would need a list of the final grades assigned to students. We will grade the papers, run all the statistical tests, analyze the results, and return a summary to you of the results from your institution as well as a summary of results from all participating institutions. We are both personally and professionally committed to this project and will give whatever assistance we can.

Once we know of your interest, we will be contacting you personally to answer any questions and discuss specifics about your needs. With so few technical colleges in the state, it is crucial that we have your participation. While it would be most beneficial if all instructors participate it is not essential; even the participation of a single instructor at an institution would be both helpful and welcome. Please discuss this with all math instructors at your institution and detach and mail the response form below back to us in the enclosed envelope. We look forward to your response and working with you on this project.

Institution:______________________________

Contact Person______________________________

Office Hours______________________________

Telephone Number__________________________

Please mark one:

__________We are interested in this project and would like to be contacted about our possible participation.

__________We are not interested in this project.

Please list any additional questions or comments in the space provided below.

September 16, 1996

Dear Professor:

Thank you again for your participation in this project. As we discussed on the phone today, you will be providing crucial numbers to our study, so I truly appreciate your pivotal involvement. Enclosed you will find the materials as I outlined earlier. If there is an error please contact me immediately and I will see that it gets corrected. If you require some special accommodation, I would be glad to discuss such a possibility with you.

Once answer keys are collected, they need to be rubber banded with a return cover sheet attached containing all pertinent information. Please return all completed answer sheets, AAT tests, and waivers to me upon completion of all testing. If there are any unused answer sheets or waiver forms, these may be discarded, but I would appreciate your returning all AAT tests regardless of condition.

In a few weeks you will be receiving forms for recording the final exam scores and final averages for each student. If you have any questions, comments, or concerns please don't hesitate to call me.

Included with this package are:

__50__AAT tests

__90__Waiver Forms

__90__Computer Answer Forms

___1__Return Cover Sheet

___1__Proctor Instruction Sheet

Sincerely,

Bruce Jones
AAT Project Coordinator
Hocking College
Nelsonville, OH 45764
Ph: (614) 753-3591 ext. 2267
email: ab192@seorf.ohiou.edu

Ohio University
Human Subject Consent Form

Title of Research:	The Arithmetic Achievement Test and Effective Placement of Students in Mathematics
Principal Investigator:	Bruce Jones
Department:	Curriculum and Instruction

The test you are about to take requires only 35 minutes. It is designed to help determine appropriate placement in mathematics. If this research proves successful, future students at this institution may get this information prior to enrolling, thus better enabling them to make a decision regarding their own personal preparedness. In addition to the score you earn on this test the investigator will also receive your final exam score and your final average grade for the course. All individual data will be kept strictly confidential however, and you will only be identified by your identification numbers. If you would like to know how you did on this test your instructor can give you details on how to receive this information. Your signature below indicates your willingness to participate in this valuable project. Thank you in advance for your valuable assistance.

I certify that I have read and fully understand the statement of procedure and agree to participate as a subject in this specific research described therein. My participation in this research is given voluntarily. I certify that I am at least 18 years of age.

Signature____ Date____________

Print Name____

AAT Return Cover Sheet

Institution Name____

Instructor's Name______________________________________

Course Title____

Course #_________________ Section #____________________

Instructions to Proctors

(1) Each student is to receive an answer sheet, a waiver form, and a copy of the AAT. Be sure that each student has a #2 pencil, and provide these to students who do not. No calculators are to be used on this test. Please anounce that students must not open their tests until you instruct them to do so.

(2) Read the following directions aloud, and ask students if they have any questions:

In the blank listed as "NAME" please put the first letter of your first name followed immediately by the last 4 digits of your social security number. For instance if your name is Joe Smith with SS# 456-45-8765 you would put J8765.

This is a multiple choice test consisting of 25 questions. Use a #2 pencil and fill in each answer bubble thoroughly, erasures need to be thoroughly erased as well. All fractions must be listed in lowest terms. You will be given 35 minutes to answer these questions. I will list the number of minutes remaining on the board in 5 minute increments until there are 5 minutes remaining. At this point, I will begin marking the *countdown* in 1 minute increments, with a verbal warning when there is only 1 minute left. Do the best job you can and answer as many questions as possible. If you find a question too difficult, skip it and come back to it later. You may guess on this test as there will be no points deducted for incorrect answers.

Your participation in this project is voluntary and greatly appreciated. If there are any questions please ask them now, for I am not allowed to answer questions during the test.

After allowing time for students to read and sign consent forms, and answering all questions as necessary:

(3) Announce "You may open your test booklets and begin the test, you have 35 minutes."

(4) Start your timer.

(5) Do the countdown as explained in the instructions above.

(6) At the end of the allotted time, instruct students to quit working and collect the answer sheets, AAT test papers, and waiver forms.

Thank you again for your participation in this project.

October 10, 1996

Dear Professor:

Thank you for your participation in the AAT Project. The one final task I need for you to complete is to record your final exam grades and final grades for the course. Enclosed you will find data sheets which should be sufficient for your needs. Please list your grading scale on the bottom of the data sheet.

I have listed the names in alphabetical/numerical order for your convenience. When recording your grades, please remember the following:

(a) The student ID# is the first letter of his first name and the last 4 digits of his Social Security number.

(b) All grades recorded on the chart need to be a percentage score. If a student has scored 150 out of a possible 200, for example, you would record 75%.

(c) Please list the grades of all students who took at least one major examination. Any student who does not have a final exam score listed will be presumed to be an incomplete (a student who did not finish the course). If, however, you don't give a final exam, please write "no" in the *complete?* column beside all grades which were incomplete.

(d) Please keep the originals in a safe place. Send me copies. This is just a precaution in case the sheets are lost in transit. I will notify you once I have received your data sheets.

Once again your participation is greatly appreciated. This study would not have been possible without your assistance, and I am both personally and professionally in your debt.

Sincerely,

Bruce Jones
AAT Project Coordinating Instructor

College ____________________ **Instructor** ____________________________

Class Name ______________________________ **Section#** __________

Grading Scale: **A:** __________ **B:** __________ **C:** __________ **D:** __________ **F:** __________

Student ID#	Final Exam	Final Grade	Complete?

Table A1.

Optimal Cut-score Contingency Table for Technical College #1

AAT Score	6	7	8	9	10	11	12	13	14	15	16	17
% of Correct Placements (drop=fail)	52	54	59	62	62	64	67	64	66	65	63	59
% of Correct Placements (completers only)	73	77	78	78	78	77	73	69	65	61	55	53

Note. Percentage of correct placements if the given score were to be used for the cut-score. Outliers have been included in this analysis.

96E-47

Ohio University
Interoffice Communication

April 3, 1996

A determination has been made that the following research study is exempt from IRB review because it involves Category 2, research involving the use of education tests and the results will not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing or employability.

Project: The Arithmetic Test and the Effective Placement of Students in Mathematics

Project Director: Bruce Jones

Faculty Advisor (if applicable): Ragy G. Mitias

Department: School of Curriculum and Instruction

Claudia L. Hale, Ph.D., Chair
Institutional Review Board

5-20-96
Date

Arithmetic Achievement Test

Do not open this test book until instructed to do so!

Directions:

(1) Filling out your answer sheet.
In the blank listed as "NAME" please put the first letter of your first name followed immediately by the last 4 digits of your social security number. For instance if your name is Joe Smith with SS# 456-45-8765 you would put J8765.

(2) Taking the test.
This is a multiple choice test consisting of 25 questions. Use a #2 pencil and fill in each answer bubble thoroughly, erasures need to be thoroughly erased as well. All fractions must be listed in lowest terms. You will be given 35 minutes to answer these questions. Your instructor will list the number of minutes remaining on the board in 5 minute increments until there are 5 minutes remaining. At this point, they will begin marking the *countdown* in 1 minute increments, with a verbal warning when there is only 1 minute left. Do the best job you can and answer as many questions as possible. If you find a question too difficult, skip it and come back to it later. You may guess on this test as there will be no points deducted for incorrect answers.

1) Reduce Completely : $\frac{36}{54}$

a) $\frac{1}{3}$ b) $\frac{18}{27}$ c) $\frac{4}{6}$ d) $\frac{12}{18}$ e) None of these

2) $\frac{1}{12}+\frac{2}{9}+\frac{4}{9}=$

a) $\frac{9}{12}$ b) $\frac{2}{3}$ c) $\frac{3}{4}$ d) $\frac{27}{36}$ e) None of these

3) $\frac{1}{6}+\frac{7}{12}=$

a) $\frac{3}{4}$ b) $\frac{2}{3}$ c) $\frac{9}{12}$ d) $\frac{8}{12}$ e) None of these

4) $\frac{1}{6}+\frac{3}{8}+\frac{3}{4}=$

a) $\frac{7}{18}$ b) $1\frac{7}{31}$ c) $\frac{24}{31}$ d) $1\frac{7}{24}$ e) None of these

5) $\frac{5}{6}-\frac{3}{5}=$

a) $\frac{2}{5}$ b) $\frac{7}{30}$ c) $\frac{1}{2}$ d) $\frac{7}{25}$ e) None of these

6) $4\frac{1}{8}-3\frac{5}{6}=$

a) $1\frac{7}{24}$ b) $1\frac{14}{48}$ c) $\frac{7}{24}$ d) $-1\frac{7}{24}$ e) None of these

7) $1\frac{1}{6}-4\frac{1}{9}=$

a) $-2\frac{1}{2}$ b) $-2\frac{17}{18}$ c) $-3\frac{1}{2}$ d) $2\frac{1}{2}$ e) None of these.

8) $4\frac{1}{2}-2\frac{5}{6}=$

a) $2\frac{1}{3}$ b) $2\frac{2}{3}$ c) $2\frac{3}{5}$ d) $1\frac{2}{3}$ e) None of these

9) $1\frac{5}{12}+2\frac{1}{2}+5\frac{3}{4}=$

a) $8\frac{1}{2}$ b) $9\frac{1}{2}$ c) $9\frac{2}{3}$ d) $8\frac{3}{5}$ e) None of these

10) Put the following fractions in ascending order (lowest to highest): $\frac{2}{3}, \frac{7}{9}, \frac{5}{6}$

a) $\frac{7}{9}, \frac{2}{3}, \frac{5}{6}$ b) $\frac{2}{3}, \frac{7}{9}, \frac{5}{6}$ c) $\frac{2}{3}, \frac{5}{6}, \frac{7}{9}$ d) $\frac{5}{6}, \frac{2}{3}, \frac{7}{9}$ e) None of these

11) ${}^{-}5+({}^{-}4)-({}^{-}2)-({}^{+}5)$

a) -2 b) +2 c) -16 d) +12 e) None of these

12) ${}^{-}0.8 + {}^{-}0.4 =$

a) 0.5 b) −0.5 c) 2 d) −2 e) 5

13) $-6(+4) =$

a) 24 b) −2 c) +2 d) −24 e) None of these

14) $-4(-2+5) =$

a) +12 b) −28 c) +28 d) −1 e) −12

15) $-2^3 - 3 =$

a) −5 b) +5 c) +24 d) −9 e) None of these

16) $\frac{-4}{+8} =$

a) −0.5 b) −2 c) 0.05 d) .2 e) None of these

17) $5.2 - 9.13 =$

a) -3.93 b) -4.13 c) -4.93 d) 3.93 e) None of these

18) $-4 + 8 - 6$

a) 2 b) 18 c) −18 d) −2 e) None of these

19) $6 - 3 \times 4 =$

a) 12 b) −6 c) −12 d) 6 e) None of these

20) $\frac{4-16}{-2+8} =$

a) +2 b) −18 c) −6 d) +6 e) None of these

If x = c − a × b, find x if a = 2, b = 3, and c = 10.

21)

a) 24 b) -24 c) -4 d) 4 e) None of these

22) In a room of 25 people, 36% are women, how many are men?

a) 16 b) 9 c) 11 d) 10 e) None of these

23) In a box of crayons 40% have been used. If 20 crayons have been used, how many crayons are there in the box?

a) 8 b) 80 c) 20 d) 500 e) None of these

24) $(-4)^2 =$

a) 16 b) -16 c) -8 d) 8 e) None of these

25) $\sqrt[3]{27} =$

a) 9 b) 3 c) 81 d) $\frac{1}{9}$ e) None of these

<EndofTest>